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SUSTAINABILITY OF FISHING OPERATIONS ALONG THE UPPER EAST COAST OF INDIA - A TECHNO-BIO-ECONOMIC STUDY

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CERTIFICATE

This is to certify that the thesis entitled "***Sustainability of Fishing Operations along the Upper East Coast of India -A Techno-bio-economic Study***" submitted for the Degree of Doctor of Philosophy in Development Studies with specialization in Economics to Dr. B. R. Ambedkar Open University, Hyderabad through Centre for Economic and Social Studies, Hyderabad is a record of the bonafide research work carried out by ***Sri. K Vijayakumaran*** under my guidance and supervision. I also certify that the thesis is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination.

It is also certified that the thesis or a part thereof has not been previously submitted by the student for any other degree or diploma of this University or any other University. The published part has been fully acknowledged.

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DECLARATION

I hereby declare that the thesis entitled "***Sustainability of Fishing Operations along the Upper East Coast of India -A Techno-bio-economic Study***" submitted for the Degree of Doctor of Philosophy in Development Studies with specialisation in Economics to Dr. B. R. Ambedkar Open University, Hyderabad through Centre for Economic and Social Studies, Hyderabad is a result of original research work carried out by me.

I also declare that the thesis or a part thereof has not been previously submitted by me for any other degree or diploma of this University or any other University. The published part has been fully acknowledged.

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ABBREVIATIONS AND ACRONYMS

ANOVA	Analysis of variance
AP	Andhra Pradesh
AUVR	Average unit value realized
BEP	Break-even point
BOBLME	Bay of Bengal Large Marine Ecosystem
CESS	Centre for Economic and Social Studies
CIFT	Central Institute of Fisheries Technology
CIFE	Central Institute of Fisheries Education
CIFNET	Central Institute of Fisheries Nautical and Engineering Training
CMA	Centre for Management in Agriculture
CMFRI	Central Marine Fisheries Research Institute
Cph/CPH	Catch per hour
CPR	Common property resource
CPUE	Catch per unit effort
CRZ	Coastal Regulatory Zone
CZM	Coastal Zone management
DAHD	Department of Animal Husbandry and Dairying
DMI	Directorate of Marketing and Inspection
EEZ	Exclusive Economic Zone
EIA	Export Inspection Agency
ESD	Ecologically sustainable development
FAO	Food and Agricultural Organization
F_{MEY}	Fishing effort for maximum economic yield
F_{MSY}	Fishing effort for maximum sustainable yield
FOC	Flag of convenience
FR	Fixed ratio
FRAD	Fishery Resource Assessment Division (of CMFRI)
FSI	Fishery Survey of India
GDP	Gross domestic product
GOI	Government of India
GPS	Geographic Positioning System
GR	Gross Revenue/ Gross Ratio
GT	Gross tonnage

GVA	Gross value added
HP	Horse power
IBM	Inboard motorised
ICAR	Indian Council of Agricultural Research
IDRC	International Development Research Centre
ICG	Indian Coast Guard
IFP	Integrated Fisheries Project
IIMA	Indian Institute of Management, Ahmedabad
INP	Indo-Norwegian Project
ISRO	Indian Space Research Organization
ITQ	Individual transferable quota
HRD	Human resources development
HSD	High-speed diesel
LIFDC	Low-income food-deficit country
LOA	Length - overall (overall length)
LRAEC	Long-run average economic cost
LRAFC	Long-run average financial cost
MBN	Mechanized bag-netter
MC	Marginal cost
MCA	Maximum contribution approach
MEY	Maximum economic/expected Yield
MFRA	Marine Fishing Regulation Act
MGN	Mechanized gill-netter
MoA	Ministry of Agriculture
MoFPI	Ministry of Food Processing Industries
MOTHS	Other mechanised units
MPA	Marine protected area
MPEDA	Marine Products Export Development Authority
MR	Marginal revenue
MSY	Maximum sustainable yield
MTN	Mechanized trawler
MZI	Maritime Zones of India (Act, 1981)
NCA	National Commission on Agriculture
NCAER	National Council for Applied Economic Research
NCDC	National Cooperative Development Corporation
NIO	National Institute of Oceanography

NM	Non-motorized /Non-mechanized units
NMLRDC	National Marine Living Resource Data Centre
NT	Net tonnage
NVA	Net value added
OB	Outboard
OBM	Outboard motorized
OBBS	Outboard motorized boat-seiner
OBGN	Outboard motorized gill-netter
OBOTHS	Other outboard motorized units
OR	Orissa / Operating ratio
OSY	Optimum sustainable yield
PFZ	Potential fishery zone
RBI	Reserve Bank of India
ROI	Return on investment
RPUE	Revenue per unit effort
RSW	Refrigerated seawater
SAC	Space Application Centre
SF	Standard effort
SL	Standard length
SRAC	Short-run average cost
ST	Steam Trawler
TAC	Total allowable catch
TL	Total length
TED	Turtle Excluder Device
TT	Technology trend
UEC	Upper East Coast
US	United States
UN	United Nations
VIU	Variable input utilization
VPA	Virtual population analysis
WB	West Bengal
WCED	World Commission on Environment and Development
WCPUE	Weighted catch per unit effort
WG	Working group

NOTATIONS, SYMBOLS AND UNITS

a	Intercept on Y-axis of a straight-line graph
B	Biomass (weight of fish in a stock)
B_0 *or* B_x	Virgin biomass (in an unexploited stock)
b	Slope of a straight-line graph
C	Catch
CR	Catch rate
CV	Coefficient of variation
C_i	Catch of a given species by i^{th} gear
C_{max}	Maximum catch
C_s	Catch by the standard gear
C_t	Catch during time period t
C_{t+1}	Catch during time period $t+1$
d	day
df	Degrees of freedom
e^x or $Exp.[x]$	Exponential value of x
E_i	Efficiency of the i^{th} gear in exploiting a given species
E*	Equilibrium (break-even) point
F	Fishing effort
F	Instantaneous rate of fishing mortality
f	Fathom
f	Fishing effort
f_i	Effort by the i^{th} gear on a given species
FC	Fixed cost
F_s	Effort by the standard gear
F_{Eq}	Effort at equilibrium
hrs	Hours
K, k	Growth coefficient
kl	Kilo litre
km	Kilometer
L	Length

L_c	Mean length at first capture
L_r	Mean length at recruitment
L_m	Mean length at sexual maturity
L_t	Length at age t
L_∞	Theoretical maximum (or asymptotic) length
L_{max}	Maximum length
$ln[x]$	Natural logarithm of x
M	Instantaneous rate of natural mortality
m	Meter
mm	Millimeter
MS	Mean sum of squares
Nm	Nautical mile
n	Number in a sample
N	Number of fish (survivors) in a stock
N_t	Number at time t
N_o	Number at the beginning (time 0)
p	Probability
R	Revenue
r	Correlation coefficient
r_s	Rank correlation coefficient
Rs.	Rupees
R^2	Coefficient of determination
S	Survival Rate
SS	Sum of squares
σ / s	Standard deviation
t	Tonnes
t	Age or time
TC	Total cost
tpd	Tonnes per day
t_o	Theoretical age at zero length
t_c	Mean age at first capture
t_m	Mean age at sexual maturity
t_r	Mean age at recruitment

t_{max}	Maximum age (longevity)
U_s	Catch per unit effort (CPUE) by standard gear
VC	Variable cost
W	Weight
W_t	Weight at age t,
W_∞	Theoretical maximum (or asymptotic) weight
Y	Yield
Y_{max}	Maximum yield per recruit
Z	Instantaneous rate of total mortality
$\Sigma(x)$	Sum of x values (from a lower to an upper limit)

CHAPTER – I

INTRODUCTION

1.1. Towards Sustainable Fish Production

Fish forms an important source of protein in the food of a significant segment of human population. Fishing is the livelihood for millions of people all over the world. Marine fisheries assume greater importance as a source of food, in view of the increasing world population and limited scope for increasing food production from land. However, the state of exploited marine fishery resources all over the world is not conducive to enhance the production for future needs. The overexploited and overcapitalized state of most fisheries of the world is posing challenges even to sustain the production to meet the present need, leave alone the future needs. Therefore, apart from promoting programmes to increase fish production by aquaculture, sustaining the production from the wild by adopting judicious resource management measures is imperative.

Sustainable fishery resource exploitation and management has different dimensions. A thorough understanding of the biological characteristics of the resource is a perquisite for deciding the sustainable level of exploitation. The technology of exploitation is based on the resource characteristics while the economics of fishing operations depends on the technology and different aspects of the resource. Thus a multidisciplinary approach is necessary for managing the exploited marine fishery resource at a sustainable level. An attempt is made in this thesis to analyse the important dimensions of the fisheries of the upper East Coast of India so as to suggest measures for sustainable fisheries management.

Before dealing with the background, objectives and methods of the study, it is necessary to have an overview of the fisheries production scenario. In this Chapter, brief reviews of the global fish production, the importance of fisheries in India and fish production in India are provided before discussing the coastal marine fisheries and the importance of the fisheries of the upper East Coast. Concluding the Chapter, the need for an integrated study is stressed.

1.2. Fish Production - A Global Perspective

World production of fish, shellfish and other aquatic animals increased from 20.7 million t in 1950 to 130.4 million t in 2000, which slightly declined to 128.8 million t in 2001. Capture fisheries production which stabilized around 94 million t during 1996-97 dropped to 87.3 million t in 1998, recovered to 94.8 million t in 2000 and again dropped to 91.3 million t in 2001. Aquaculture production showed steady growth from 6.9 million t in 1984 to 37.5 million t in 2001. The fluctuations in capture fisheries production was mainly due to the fish stocks in the Southeast Pacific, which responded to the effects of the *El Niño* atmospheric phenomenon. China, The largest producer of fish in the world (total production of 41.6 million t) recorded capture fisheries production of 17 million t in 2000. Other major capture fish producers were Peru (10.7 million t), Japan (5.0 million t), the United States (4.7 million t) and Chile (4.3 million t). Aquaculture production from both inland and marine waters continued to increase in 2001 and the Asian region, particularly China continued to dominate world production (FAO, 2002[a]).

Fish is an important component of food of a majority of the world population. In 2001 over three quarters (99.4 million t) of the global production of fish, crustaceans and molluscs were utilized for direct human consumption. Of this, consumption in fresh form accounted for the bulk (53.7 percent) followed by frozen fish (25.7 percent), canned fish (11.0 percent) and cured fish (9.6 percent). The share of animal protein derived from fish in human food increased from 13.7 percent in 1961 to 16.1 percent in 1996 and came down to 13.1 percent in 2000 (FAO, 2002[a]).

In 1999, international trade of fish and fishery products, traded both as food and feed products, were close to 43 million tonnes – an increase of 11 percent compared to the previous year. In 2000, fish imports reached a new record of US $ 60 billion, of which developing countries contributed more than 80 percent. The net foreign exchange earnings by developing countries increased from US $ 2.7 billion in 1980 to US $ 18 billion in 2000. During the year 2000 Thailand, with US $ 4.4 billion worth of fish trade, continued to be the leading exporter followed by China with US $ 3.7 billion (FAO, 2002[a]).

Japan continued to be the world's leading importer of fish products in 2000 too, accounting for 26 percent of the world total. Imports by Japan, the United States and the European Union increased by 6 percent, 12 percent and 9 percent, respectively, compared to 1999. In 2000, 74 percent of Japan's fish imports were in fresh, chilled or frozen form. Crustaceans accounted for about 29 percent of total imports, the bulk (69 percent) of which being shrimps. Tunas represented 13 percent of total fish imports. The United States, which increased its imports by nearly US $ 2.0 billion, was the second largest importer. Valued at US $ 3.8 billion, shrimp imports accounted for 37 percent of United States' imports of total edible fish products. Spain was again the leading importer of fish and fishery products within the European Union, followed by France, Italy, Germany and the United Kingdom. With catches of small pelagics for reduction regaining the levels prevailing before *El Niño*, fishmeal exports in 2000 were about a million t above the 1999 exports. China is becoming one of the largest fishmeal consumers in the world. In 2000, it imported 1.1 million tonnes, almost doubling the imports of the previous year. Forty percent of its fishmeal imports were used in aquaculture (FAO, 2002[a]).

1.3. Importance of Marine Fisheries in India

Among the countries bordering the Indian Ocean, India tops in fish production accounting for almost 35 percent of the total production from this fishing area and contributing nearly about 4.5 percent to the world fish production. The country is bestowed with a lengthy coastline of about 8118 km, a continental shelf area of about 0.5 million km^2 and an Exclusive Economic Zone (EEZ) of 2.02 million km^2. With a production of 5.6 million t in 1999-2000, India has been changing between fifth and seventh place among the fish producing nations of the world since 1987. India also occupies second position in shrimp production, contributing nearly 10 percent (2.8 lakh t) of the total world shrimp production.

Fishery forms an important sector of the country's economy. There are about 2.6 million full-time fishermen, 1.4 million part-time fishermen and 2.1 million occasional fishermen employed in this sector. The contribution of fisheries in 1970-71 to the country's GDP at current prices was a mere Rs.245 crores accounting for 0.6 percent of the total and 1.5 percent of agriculture sector (MoA, 1994). During 1998-99 the contribution of fisheries to GDP increased to Rs.22.2 thousand crores accounting for 1.4 percent of the total and 4.7 percent of the agriculture sector (MoA, 2001).

The marine product exports from the country were about 20 thousand t valued Rs.25 million in 1950. The export value crossed Rs.100 million during 1966 and 1 billion US $ mark in 1994. In the year 2000, about 0.42 million t of marine products worth Rs.64 billion were exported from India (MPEDA, 1998 and 2001).

Increasing demand due to the population growth as well as changing food habits and stagnating supplies had been widening the demand-supply gap of fish, which has been estimated to become 20 million tonnes by the turn of the 20^{th} century. In contrast to the commanding position in fish production, the per capita availability of fish in India is one of the lowest in the world. Compared to the world's annual average per capita fish availability of 11-12 kg and developed countries' annual average availability of 24 kg, India has got a poor 3 kg per capita (Mukerji, 1986). Another publication stated that the per capita availability of fish to the fish eating population in the country is about 8 kg per year and it has been envisaged to increase the availability to 11 kg per annum during the 9^{th} five year plan (Anon., 1995). Despite the shortage in supply, fish has remained the cheapest protein food in India, though the prices have started moving up recently.

1.4. Fish Production in India

India's fish production rose from a mere 0.75 million t in 1950-51 to 5.6 million t in 1999-00. The marine fish production during this period increased from 0.53 million t to 2.83 million tonnes. The inland fish production rose from a mere 0.22 million t in 1950-51 to 2.82 million t in 1999-00. While marine fish production has come to stagnate in recent years, inland fish production is steadily growing. The growth in marine products exports was dramatic, beginning with a meager 20000 t valued at Rs.25 million in 1950-51 the exports reached 0.38 million t valued at Rs.41 billion during 1996-97. Though the quantity fluctuated slightly during subsequent years, the export earnings steadily increased to cross Rs.50 billion during 1999-00. The growth in production and exports was slow during fifties, which gathered momentum during 1960's and 1970's and again started slowing down during the late 1980's. The data on production and exports at the beginnings of early three decades from 1950 and recent years provide a clear picture of this trend (Table - 1.1). However, individual sub-sectors such as aquaculture had been showing altogether different trends.

Table - 1.1. Quantity of fish production and exports (in lakh tonnes) and value of export (in Rs. Crores) in India at selected points in time during 1950 –2000

	Production			Exports	
	Marine	**Inland**	**Total**	**Quantity**	**Value**
1950 – 51	5.3	2.2	7.5	0.2	2.5
1960 – 61	8.8	2.8	11.6	0.2	3.9
1970 – 71	10.9	6.6	17. 6	0.4	35.1
1980 – 81	15.6	8.9	24.4	0.8	234.8
1990 – 91	23.0	15.4	38.4	1.4	893.4
1991 – 92	24.5	17.1	41.6	1.7	1375.9
1992 – 93	25.8	17. 9	43.7	2.1	1767.4
1993 – 94	26.5	20.0	46.4	2.4	2503.6
1994 – 95	26.9	20.9	47.9	3.1	3553.1
1995 – 96	28.3	21.3	49.5	3.0	3501.1
1996 – 97	28.6	22.8	51.4	3.8	4121.4
1997 – 98	29.5	24.4	53.9	3.8	4697.5
1998 – 99	27.0	25.7	52.6	3.0	4626.9
1999 – 00	28.3	28.2	56.1	3.4	5095.7

Source: Ministry of Agriculture (MoA), Govt. of India.

1.5. Coastal Marine Fisheries

Coastal marine fishing in India is the livelihood for 5 million fishers living in 3,651 coastal fishing villages and provides employment for more than a million active fishermen. The gross investment on fishing component is estimated to be Rs.42 billions (at 1996 price). The annual (1997) production is valued at Rs.74 billion (Devaraj and Vivekanandan, 1999). There are 2,271 fish landing centres, six major fishing harbours, 27 minor fishing harbours from which 47,000 mechanized vessels, 36,500 motorized vessels and 0.15 million artisanal crafts operate. A number of freezing plants (372), canning plants (14), ice plants (148) fish meal plants (15), cold storages (450) and peeling sheds (900) support the processing and post-harvest of marine fish catch. Over the years, there was significant growth in the fishermen population as well as fishing units (Table-1.2).

During pre-independence period the marine fisheries in India was a traditional subsistence activity. During the post-independence period planned development and promotional programmes brought in several structural changes in the fisheries sector. The thrust areas of fisheries development in the country during different plan periods are summarized in Table-1.3.

The promotional measures of the Government had tremendous impact on the marine fisheries sector. Synthetic net materials almost totally replaced the natural fibres and considerably enhanced the fish catching efficiency and durability of gears. Introduction of mechanized vessels, diversified fishing like purse seining and motorization of traditional crafts significantly boosted the fish production. India has declared 200 miles Exclusive Economic Zone (EEZ) in 1976 by an Act of Parliament (Khan, 1997). This bestowed on her the exclusive right to exploit, conserve and manage the living and non living resources of 2.02 million square km

Table - 1.2. The changing numbers of marine fishing villages, fishermen population, and number of crafts in India over different periods.

Period	1961-62@	1973-77@	1980@	1999#
Fishing villages	1797	1913	2408	3651
Fishermen population	959937	1435158	2096314	5000000
Active fishermen	229345	322532	474731	1000000
Traditional boats	90424	106480	140833	150000⊗
Mechanised boats	0	8086	19013	47000

Source: @ James, 1989; # Devaraj and Vivekanandan, 1999
⊗ Does not include 36500 motorised boats

Table - 1.3. Thrust areas of marine fisheries development in India through the plan periods from 1951-1996.

Plan and Period	Major developments in marine fisheries sector during the Plan period	Average annual marine catch (t)
I Five year plan (1951-1955) II Five year plan (1956-1960)	i) Mechanisation of indigenous artisanal fishing craft. ii) Introduction of mechanized fishing vessels. iii) Introduction of modern gear materials. iv) Infrastructure for preservation processing storage and transportation.	565412 730699
III Five year plan (1961-1965) Three annual plan (1966-1968)	i) Substantial increase in the use of synthetic gear materials. ii) Export trade.	730061 904355
IV Five year plan (1969-1973)	i) Import of trawlers for deep-sea fishing. ii) Indigenous construction of deep-sea trawlers. iii) Fishing harbours, major minor ports. iv) Intensification of exploratory fishery surveys. v) Expansion of export trade	1070264
V Five year plan (1974-1978)	i) Diversification of fishing, introduction of purse-seining	1326408
One year plan (1979)	i) Diversification of products. ii) Motorisation of artisanal crafts	1365739
VI Five year plan (1980-1984)	i) Exploratory Surveys in Offshore grounds. ii) Declaration of EEZ in 1976. iii) MZI Act 1981 for regulation of foreign fishing vessels. iv) Promotion of Deep-sea fishing through licensing chartering and joint venture.	1434914
VII Five year plan (1985-1989) Two annual plans (1990-91)	i) New chartering policy of 1999. ii) Development of deep-sea fishing. iii) Growth of motorised artisanal ring-seiners. iv) Coastal shrimp aquaculture	1769040 2182412
VIII Five year plan (1992-1996)	i) Deep-sea fishing by joint venture. ii) Development of coastal aquaculture. iii) Substantial growth of motorised artisanal ring-seiners. iv) The changed orientation of export-trade from resource base to food engineering.	2295889

Source: adapted from Devaraj et al., 1997.

of EEZ located between the latitudes 03°00' and 24°40' N and longitudes 65°00' and 97°00' E. Since then, development of deep-sea fishing was identified as one of the priority areas by the fisheries development authorities.

Different phases could be identified in the planned development of marine fisheries sector (Devaraj and Vivekanandan, 1999). During 1950-1962, the coastal fisheries in India remained in the *pre-developed phase* with an average production below 0.8 million t. The prolonged *growth phase* (1963-1988) that followed witnessed intensive mechanization and steady increase in annual catches from 0.8 to 1.8 million t. The *fully exploited phase* (1989-1999) saw a further boost in production from 1.8 to 2.7 million t, by exploiting the under-exploited resources and areas. The current stagnation in production, in spite of increase in effort, indicates an *overexploited phase*. Unless proper control measures are taken, it is natural that the fishery may enter a *collapsed phase* from which recovery may take several years.

The marine fishing in the country is mostly concentrated in the inshore area (<50 m depth) of about 0.18 million km^2, which has an estimated potential of 2.2 million t (equal to the current production). The qualitative and quantitative distribution of fishery resources and the economics of operation compel all types of fishing vessels to operate within the inshore waters. Vijayakumaran (1998[a,b], 1999[a]) mentioned that even the deep-sea fishing vessels confined their operations within 50 m depth most of the time. The scenario of expanding number of fishing units harvesting a fixed resource base recapitulates typically *the tragedy of the commons* (Hardin, 1968). The impact can be well understood by looking at the growth (change) in fishermen population in relation to unit inshore area as well as per capita annual production from two points of time (Table-1.4). It could be seen that except in Orissa the entire coastline has been facing a decline in per capita fish available to fishermen.

Table - 1.4. Changes in the estimated number of fishermen per square km of inshore area (<50-m depth) and production per fishermen from two points of time.

	Active fishermen per km^2			Annual Production (t) per fisher		
State	**1961-62**	**1996-97**	**Change %**	**1961-62**	**1996-97**	**Change %**
West Bengal	0.3	2.2	633	2.1	1.9	-10
Orissa	0.3	2.4	700	0.5	0.5	20
Andhra Pradesh	2.9	7.6	162	1.3	0.7	-46
Tamil Nadu	2.4	5.2	117	2.0	1.8	-10
Pondicherry	9.6	38.6	302	1.8	0.6	-67
Kerala	5.9	16.5	180	2.5	1.7	-32
Karnataka	1.1	9.7	782	5.3	1.3	-75
Goa	2.4	4.3	79	2.9	2.9	0
Maharashtra	0.8	3.2	300	6.1	3.5	-43
Gujarat	0.2	1.0	400	8.4	6.0	-29
All India	**1.3**	**4.4**	**238**	**3.5**	**1.9**	**-46**

Source: adapted from Devaraj and Vivekanandan, 1999.

Planned development and promotion of technology resulted in capital-intensive industrial fishing to occupy an important place in the marine fisheries sector. Thus marine fisheries sector in India exhibited a characteristic dualism (Panayotou, 1985) -coexistence of large-scale industrial fisheries and small-scale subsistence fisheries side by side. The impact of declining catch affected the two sectors differently. The small-scale sector being more labour intensive, using more of renewable energy and causing less environmental repercussions (Swaminathan, 1981), has been less affected. The mechanized sector has to face hardship of the combined impact of declining catch and escalating operating costs. The management of marine fisheries involving two separate sectors with different technical, social and economic features and exploiting a common resource poses several challenges.

1.6. Upper East Coast in Indian Fisheries

Among the maritime states of India, the three States bordering the upper East Coast (UEC) namely West Bengal, Orissa and Andhra Pradesh together contribute to about 11 percent of the total marine fish landings. The three states account for 26 per cent of the country's coastline and 13 percent of the continental shelf area. About 48 percent of the fishing villages and 27 percent of the landing centres are located in this region. Nearly 31 percent of the country's total active fishermen are engaged in fishing activities along this coast. Some important particulars pertaining to the marine fisheries of the three States are presented in Table-1.5.

The total marine fish landings from the three states ranged between 0.12 million t and 0.35 million t with an average of about 0.23 million t during 1975-99 period. Andhra Pradesh topped the three states in landings, contributing about 62 percent followed by Orissa (20 percent) and West Bengal (18 percent). The marine fish production from the three maritime states of the upper East Coast during selected years and recent period is given in Table-1.6.

Table - 1.5. Basic particulars pertaining to the marine fisheries of the three maritime states of the upper East Coast.

Sl. No.	Particulars	West Bengal	Orissa	Andhra Pradesh	Total UE coast	India Total
1.	Coastline (km)	650	480	974	2104	8129
2.	Continental shelf area < 200 m (km^2)	20000	25000	31000	67000	500000
3.	Number of fishing villages	303	263	453	1019	2132
4.	Number of landing centers	47	68	280	395	1438
5.	Number of active fishermen	19756	30,724	83903	134383	437899
6.	Potential brackish water area	405000	31600	150000	586600	1190900

Source: compiled from different sources

Table -1.6. Marine fish production (thousand tonnes) from the three maritime States of the upper East Coast in selected years (periods) from 1969-1999

Year	West Bengal	Orissa	Andhra Pradesh	Total upper East Coast	All India Total
1969	8	15	76	100	914
1979	11	41	91	144	1388
1989	37	47	123	207	2230
1990	50	65	118	233	2162
1991	67	45	121	233	2222
1992	79	48	150	276	2277
1993	92	62	168	322	2245
1994	61	48	167	276	2341
1995	73	43	149	265	2174
1996	75	54	163	292	2415
1997	75	46	193	314	2726
1998	88	44	190	323	2670
1999	56	58	233	347	2435

Source: CMFRI Publications

1.7. The Need for an Integrated Study

In the recent past, the fishing pressure on the coastal resources intensified to a great extent due to increase in number of different types of fishing crafts all along the coast. Due to the inherent techno-economical factors all types of vessels, including the deep-sea vessels, were fishing in the near-shore waters. Motorisation of traditional crafts, which has picked up in a big way all along the coast unfortunately has not brought any qualitative changes in the fish production. On the contrary, the cost of motorization and enhanced operational expenses has become an additional burden to the traditional motorised units.

As in any common property resource, many adverse developments have happened in the fishery of the upper East Coast. Many of the stocks are exploited beyond optimum and the industry is over-capitalized (Vijayakumaran, 1999[a]). The existing externalities and depletion of resources are posing a severe threat to the livelihood of the artisanal sector. Ecologically sustainable development (ESD) advocates meeting the present needs without compromising the ability of the future generations to have the same privilege. This warrants development based on sustainable use of species and ecosystems, the maintenance of essential ecological processes and preserving biological diversity.

The regulatory and management measures currently being practiced are not sufficient to turn the system towards sustainability. Studies hitherto carried out in this area had considered limited aspects into account and were inadequate to provide a holistic picture or suggest some viable solutions. The need for undertaking an interdisciplinary study taking the various dimensions into account is therefore severely felt. The present study, which integrates the three important aspects, namely technology, biology and economics is an attempt to analyse the issues within a broader frame.

This study envisages an interdisciplinary approach to understand the issues of sustainability of the harvesting sector of the fisheries along the upper East Coast of India. However, the main emphasis would be on the economic performance of important types of fishing units. It is envisaged to provide a coherent and concise appraisal of the fishery of the upper East Coast and analyse the important issues, explore the opportunities and provide the options for sustainable resource management and inputs for policymaking.

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CHAPTER – II

BACKGROUND AND METHODS

CHAPTER - II

BACKGROUND AND METHODS

2.1. Introduction

Since the introduction of mechanised fishing in 1960s, the developments in the marine fisheries sector along the upper East Coast have been very dramatic. The popularization of bottom trawling and location of new fishing grounds resulted in proliferation of small and medium sized mechanised trawlers and introduction of larger imported trawlers. Adoption of synthetic netting materials, promotion of motorization, and introduction of fiberglass beach landing crafts enhanced the capability and efficiency of the traditional fisheries. All these developments helped to increase the marine fish production from the upper East Coast of India. The adoption of new technologies and resultant structural transformations also increased the dimensions and complexity of the fishery environment.

Management of marine fisheries essentially involves resolving issues and conflicts in optimum resource use by different stakeholders. The optimum exploitation of resources using the best mix of fishing effort and preserving the health of fish stocks is the broad objective of ESD in marine fisheries. In a complex system with multiple parameters and competing objectives, the process of decision-making involves formidable challenges. In this Chapter an attempt is made to provide a suitable background to the interdisciplinary topic being attempted in this thesis by reviewing briefly the major works in relevant areas. The overall objectives and scope are briefly dealt with before outlining the broad methodology of the study.

2.2. Background of the Study

Fisheries Research in India has a long history going back to the pre-independence colonial period. There was a change in focus of marine fisheries research as the country passed through various phases of development (Devaraj and Vivekanandan, 1999). A perusal of the literature reveals that in the early years, main attention of the researchers has been on the biology, ecology, taxonomy and distribution of fishery resources and description of the fishing techniques. Fishery biology and taxonomy were components of the marine biological research, which slowly picked up during the pre-independence period in some universities and State fisheries departments. Research in marine fisheries in India gained momentum in the post-independence period mainly under the aegis of various research organizations like Central Marine Fisheries Research Institute (CMFRI), Fishery Survey of India (FSI), Central Institute of Fisheries Technology (CIFT) and various Universities.

2.2.1. Exploratory Surveys

Biological investigations as well as resource exploration and mapping were the dominant research agenda up to early nineteen eighties. The earliest important works on marine fisheries of the East Coast of India were based on the results of the experimental trawling conducted at different points of time under the aegis of various inter-governmental programmes (FAO/UN, 1961 and 1962; Shariff, 1961; Poliakov, 1962; Kuthalingam *et al.*, 1963). Results of the early organized exploratory trawl surveys published by various workers revealed the offshore demersal fishery potential of the East Coast (Nagabhushanam, 1971; Sekharan *et al.*, 1973; Kuthalingam *et al.*, 1973; Krishnamoorthi, 1976). While Sebastian *et al.* (1964) detailed the results of the experimental prawn trawling conducted off Kakinada, Antony Raja (1980) provided an overview of the resources of the shelf area of Bay of Bengal. The existence of a good prawn fishery off West Bengal was revealed in some of the works (Sudarsan and Joseph, 1975; Sudarsan, 1977). Information from these sources served as the basis for development of marine fisheries, especially introduction of mechanized shrimp trawlers along the upper East Coast.

2.2.2. Resource Information, Status and Reviews

As the fishing industry became a prominent sector and commercial exploitation of fishery resources intensified, status reports and trends of landings were published periodically by agencies such as CMFRI. A number of publications summarizing the research findings of several years also came out from CMFRI. Dharmaraja and Varughese Philipose (1977) analysed the trend in the yield of major exploited fisheries of the East Coast of India. Industrial fisheries of Visakhapatnam coast based on exploratory surveys during 1972-78 figured in a subsequent work (Anon., 1980).

For promotion of deep-sea fishing, many attempts were made to provide an overall appraisal of the fishery resources of the Indian EEZ (George *et al.*, 1977; Joseph, 1987; Sudarsan *et al.*, 1988 and 1990; Sudarsan, 1993). The work by Sudarsan and Somvanshi (1988) focused on the fishery resources of the upper East Coast. Since 1990, periodic revalidations of resources of the EEZ were being carried out by the Working Groups of experts (WG-I and WG-II) constituted for this purpose (Anon., 1991 and 2000).

Apart from these, there were also a few works, which provided status and summaries of marine fisheries of Orissa (Roy, 1981), commercial trawl fisheries off Kakinada (Muthu *et al.*, 1977) and marine fisheries of West Bengal (Dan, 1985). Murty (1994) reviewed the contributions of CMFRI to the research and development in marine fisheries of Andhra Pradesh. Radhakrishna and Murty

(1993) reviewed the present status of fisheries management and catch forecasting in India.

Marine Fish Calendars published for Kakinada (Murty *et al.*, 1988) and Visakhapatnam (Luther *et al.*, 1988) provided seasonal abundance of various commercially important species in the respective areas. The appraisal of the marine fisheries of West Bengal (Varughese Philipose *et al.*, 1987), Orissa (Scariah *et al.*, 1987) and Andhra Pradesh (Alagaraja *et al.*, 1987) were comprehensive and reviewed the information available till date on various aspects of marine fisheries of theses states. Reuben *et al.* (1989) made a detailed analysis of the bottom trawl fishery of the upper East Coast.

2.2.3. Assessment and Management

As the exploitation intensified with addition of more and more number of vessels, the need for fish stock assessment and suggestion of management measures were felt imperative. Since nineteen eighties a shift in focus to assessment of fish stocks could be observed in the research outputs. The various tools and techniques of fish stock assessment has been reviewed by Alagaraja (1983, 1984 and 1989). Training initiatives and software development programmes by FAO were very effective in popularizing the application of stock assessment methods and tools (Sparre *et al.*, 1989) Many researchers attempted stock assessment of commercially important (individual) species from selected localities.

The issues in tropical multi-species fish stock assessment detailed by Pauly (1979) have been discussed in the Indian context by Murty (1987) with particular reference to demersal fisheries. Assessing the mixed fisheries stocks of five important demersal species in the trawling grounds off Kakinada, Murty (1989) has advocated a radical change in the approach of the stock assessment studies. Understanding the limitations of the single species limited area fish stock assessment, efforts have been made subsequently to consolidate the data and assess the stocks assuming a wider area of distribution. Thus stock assessment of pelagic resources such as mackerel (Noble *et al.*, 1992), ribbonfish (Thiagarajan *et al.*, 1992) carangids (Reuben *et al.*, 1992), white baits (Luther *et al.*, 1992) and Hilsa shad (Reuben *et al.*, 1992) were conducted for the entire Indian seas. Similarly, stock assessment of demersal fishes such as sciaenids (Appa Rao *et al.*, 1992), threadfin breams (Murty *et al.*, 1992) catfishes (Menon *et al.*, 1992) silver bellies (Murty *et al.*, 1992) and crustacean resources such as penaeid prawns (Rao *et al.*, 1995) were also carried out on an all India basis.

2.2.4. Technology, Economics and Marketing

The initial process of mechanization of fishing vessels, which started in nineteen sixties along Andhra Pradesh coast has been reported by Rao and Devara (1962). Various authors have reported the mechanisation, adoption of modern synthetic fibres for net and other important changes that have been taking place in the harvesting sector at different points of time. While Panicker *et al.* (1977) reported on the comparative efficiency and economics of double rig shrimp trawling, Rao *et al.* (1980) studied the impact of mesh size reduction of trawl nets on the prawn fishery of Kakinada. The All India Marine Fisheries Census conducted in 1980 by CMFRI (CMFRI, 1981) has taken a complete inventory of the marine fishermen population and their fishing gadgets in India. During 1998 CMFRI updated the available information on craft and gear by conducting a rapid survey on all India basis. Chittibabu *et al.* (1988) reported introduction of 43 feet vessels, the *Sona* boats, along Andhra Pradesh coast.

Rao (1983) has provided an overview of the various aspects of fisheries economics and management in India. As mechanization of fishing craft and adoption of new technologies continued changing the face of the marine fisheries sector, many researchers felt the need for study of the economics of operation of fishing units. Subba Rao (1986 1988 and 1999) made case studies on the economics of fisheries with reference to Andhra Pradesh and mechanization and marine fishermen at Visakhapatnam and discussed the strategies for better performance of mechanized fishing. There were many limited and isolated attempts to study the economics of operation of fishing units along the upper East Coast. Along the West Bengal Coast, comparative efficiency of different craft-gear combinations (Datta and Dan 1988[a]) as well as comparative efficiency of different types of bag nets (Datta and Dan 1988[b]) has been studied. Along the Orissa coast, various authors have worked on the input-output relationship in capture fishery (Datta and Dan 1985), productivity, profitability and income distribution as well as financial feasibility in capture fishery (Datta *et al.*, 1989[a] and 1989[b]) and economics of different craft gear combinations (Datta *et al.*, 1989[c]).

Very few studies have been made on the operations and economics of the deep-sea fishing vessels. In a pioneering study by Unnithan *et al.* (1985), the economic performance of 22 and 23 m deep-sea trawlers operating from Visakhapatnam has been analyzed. Rao (1987, 1988 and 1993) has studied the prawn fishery of the upper East Coast exploited by the large trawlers and suggested the optimum number of trawlers required for exploitation of the resources. Vijayakumaran (1992) has analyzed the effect of diesel (HSD) subsidy given to the deep-sea fishing units and indicated how subsidy create false profit and attract further increase in fishing effort. Giudicelli (1992) has made a study on the deep-sea fisheries development in India and proposed measures for diversification of vessels in a phased manner.

Price and marketing of fish remained the least studied subject along the upper East Coast. After Philips (1947) provided some suggestions for improvement of production and marketing of fish in Bengal, periodic accounts of marketing of fish in India were published in later years (GOI, 1961). There was a detailed analysis of the demand for fish and its storage and transport in selected cities of India by NCAER (1980). The Centre for Management in Agriculture (CMA) of Indian Institute of Management (IIM), Ahmedabad made an important comprehensive study on marine fish marketing in India (CMA, 1984). Ganapathy (1978) discussed the scope for diversification of marine products for exports. Some authors discussed the price policy for marine fish (Rao, 1971) and price behaviour of Indian frozen shrimp in the US market (Saxena, 1970). Considering the extreme price fluctuations in the market, Ramakrishnan (1981) discussed the issue of fixing minimum price for fish.

2.2.5. Interdisciplinary Studies.

Many authors advanced the concept and models of bioeconomic analysis in fisheries (Clark and Kirkwood, 1979; Clark, 1985; Hanneson, 1993; Campbell *et al.*, 1993). Vijayakumaran (1993) discussed the advantages of applying bioeconomic models in fisheries management. An interdisciplinary approach to study the demersal trawl fishery of the upper East Coast was initiated by FAO in 1991, which resulted in a workshop on the bio-economics of the north-eastern demersal fishery in 1993 (FAO, 1993). Subsequently, Verghese (1994) made a techno-economic study of the larger vessels of the upper East Coast. Vijayakumaran (1998[a]) analyzed the exploitable potential of the Indian EEZ in the techno-economic background. The externalities and sustainability of exploitation of the fishery resources of the EEZ was examined in a subsequent analysis (Vijayakumaran, 1998[b]).

It could be seen that most of the studies were confined to limited areas in selected locations. The stock assessment exercises carried out on all India basis during nineties assumed wider geographical area. But the results were not amenable to be translated into policy initiatives. The concept of upper East Coast as a unit for management has been promoted by the FAO's Bio-economics workshop (FAO, 1993). However, this study confined to the demersal fishery resources of the UEC and did not consider pelagic resources and some important types of fishing units.

Studies confining to limited space and aspects are likely to give only a partial view of the problems in the fisheries sector. Results of such studies will be inadequate to provide inputs for regulation and management or suggest viable and lasting solutions to turn the system towards sustainability. This study attempts to fill the lacuna of an interdisciplinary study taking the three important aspects, namely technology, biology and economics on a wider geographical frame.

2.3. Scope and Objectives

2.3.1. Scope of the study

This study envisages an interdisciplinary approach to understand the overall sustainability of fishing operations along the upper East Coast of India. The study has considered the coastal marine fisheries of the three maritime States of the upper East Coast of India, namely West Bengal, Orissa and Andhra Pradesh.

The maximum sustainable yield has been estimated at macro level for pelagic and demersal groups (not at species level) based on data for 1990-1999. The study focuses on the performance of the important types of fishing units such as different types of trawlers, mechanized gill-netters, outboard motorized units and non-mechanised fishing units operated over a wider geographical area. The vessels operating passive gears such as bag nets, shore seines etc. in limited localities are not being considered for detailed analysis.

2.3.2. Objectives

The broad objective of the study is to analyse the biological, technological and economic aspects of the harvesting sector of the marine fisheries along the upper East Coast of India from the perspective of sustainable resource management. The study would specifically envisage:

- To examine the biological characteristics of exploited of fishery resources and take inventory of the potentials in the light of present trend in exploitation along the upper East Coast of India
- To examine the technological aspects of important fishing methods, craft and gear along the upper East Coast of India and assess their capabilities.
- To analyse the important aspects of marketing and price of fish from the point of sustainability.
- To investigate the pattern of investment and economics of operation of the different classes of vessels identified.
- To estimate the biologically sustainable yield from the fishery of the upper East Coast of India and to arrive at the optimum number of different class of vessels that can be sustained by the fishery.

2.3.3. Hypothesis

This study would examine the various biological, technological and economic parameters of the harvesting sector of the fishery of the upper East Coast of India in order to evaluate the following general hypothesis:

> *'The present pattern of exploitation of the marine fishery resources along the upper East Coast of India is biologically sustainable and the technology of operations of fishing units are economically sustainable.'*

2.4. Approach to Study

2.4.1. Area of Study

The area of present study, the upper East Coast of India has been conveniently termed as the Northeast Coast of India or the northwestern part of Bay of Bengal by various authors. Different workers have defined the boundaries of Northeast Coast of India in various ways. In some previous studies (Sudarsan *et al.*, 1988; Reuben *et al.*, 1989) the area between 15 ° N and 21 ° N latitude, which includes the coasts of West Bengal, Orissa and part of Andhra Pradesh, north of Kakinada (Fig.2.1) has been considered as upper East Coast. FAO (1993) denoted the area between 16 ° N and 22 ° N latitude as the Northeast Coast of India. Certain other sources such as Annual Reports of CMFRI have been conventionally categorizing Andhra Pradesh in the Southeast Coast and Orissa and West Bengal in the Northeast Coast.

The present study distinguishes the upper East Coast of India as the seas adjoining the Indian coastline above 15 ° N latitude in the Bay of Bengal. This is because of the following reasons:

- Estimates of resources made based mainly on the exploratory data of FSI identify similar geographical area.

- The operational range of the dominant class of vessels in the present study generally falls within this region.

- There are many environmental and oceanographic characteristics, which determine the abundance of fishery resources, common to this region.

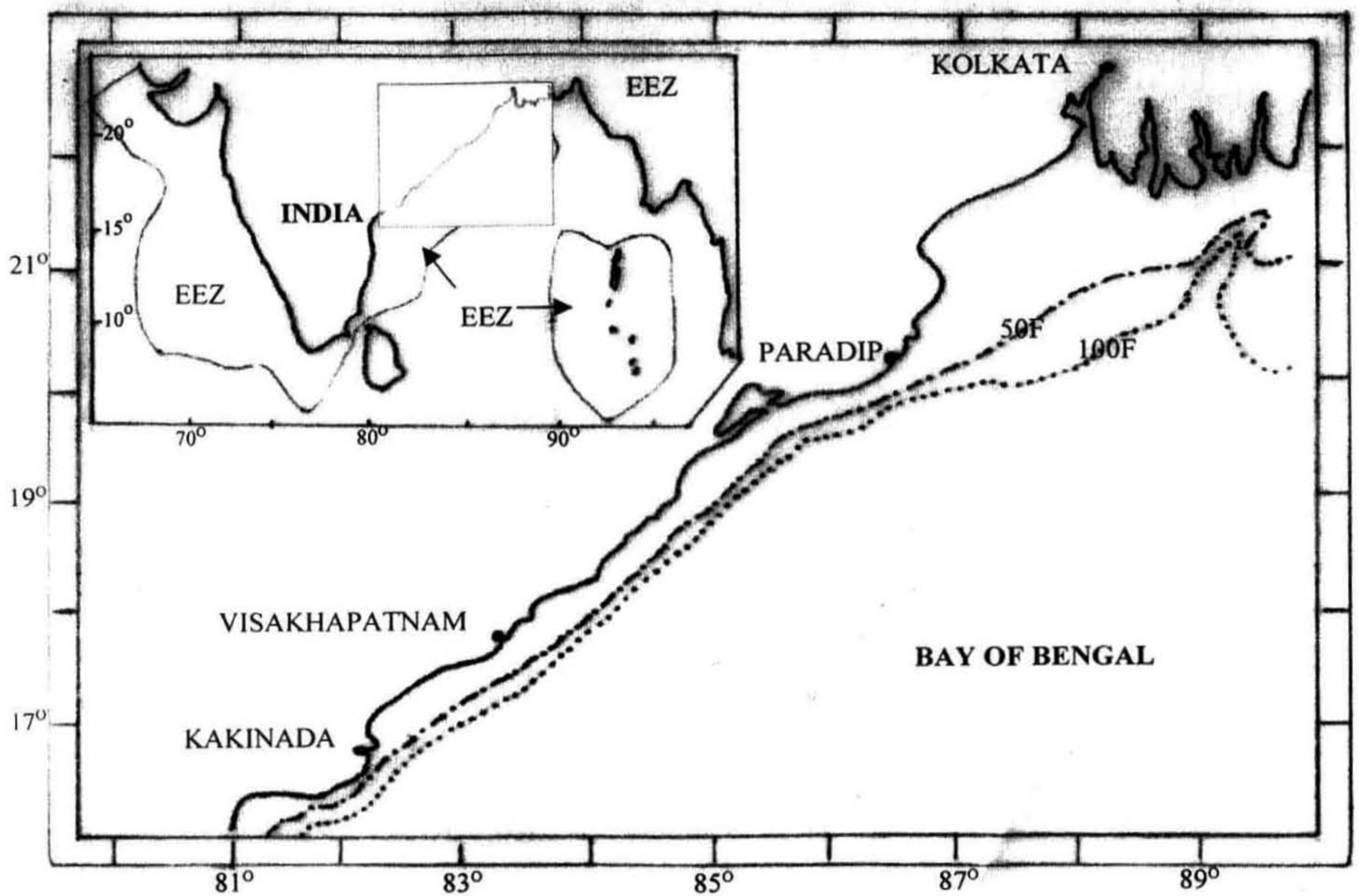

Figure.2.1. Map showing the Indian EEZ and the study area

Three maritime States namely Andhra Pradesh, Orissa and West-Bengal have been included under the upper East Coast. Inclusion of Andhra Pradesh in UEC is justified because major part of the coastline of Andhra Pradesh is above 15 ° N and certain sets of data (fish landing data for 1990-1999) pertaining to the north Andhra Pradesh coast are not separable.

2.4.2. Sampling of Fishing Units

The diversity of craft and gears along the upper East Coast being great, inclusion of all of them in a particular study is extremely difficult. Therefore, a selection of important gears has been made to make detailed study, while the catch and effort of total stock is considered for overall analysis. The selection of craft and gear for the study has been made based on the relative importance under the criteria like predominance in number, spatial distribution and representation in the three maritime States, level of investment, employment generated, critical vulnerability and special importance.

Primary data on the technological aspects and economic variables of different types of fishing crafts and gear have been collected using a questionnaire (Appendix-A) directly from the field. Considering the vast number of landing centres and a variety of craft and gear, samples of dominant class of fishing units have been drawn from important landing centres/ fisheries harbors located at Kakinada, Pudimadaka, Visakhapatnam, Chintapalli, Gopalpur, Paradip, Dhamara, Dhiga, Junput and Frazergunj. Instead of a random sample of all units, a purposive sample of 'best practice' units has been selected to understand sustainability of fishing operations under the best of the existing conditions. Pretty *et al.* (2003) have adopted a similar approach in their study.

Data from four different types of trawlers (97 units) gill-netters (22 units) OBM units (30 units) and non-mechanised units (34 units) were collected using questionnaires (detailed breakup given in Chapter –VII). The help of survey staffs of CMFRI at different field centers and skippers and crew of a number of private boats has been used in the collection of relevant information. Only the operational data for the period 1998-2000 have been considered for the analysis. This has been supplemented with secondary information from published sources.

2.4.3. Sources of Information

Depending upon the requirement and availability, both primary and secondary data have been used in this study. The different data that were used in the study and their sources are detailed below.

Apart from the primary data on the technological and economic variables collected using a questionnaire, primary data on ex-vessel price of fish landed has been collected from Visakhapatnam Fisheries Harbour by fortnightly survey during 1995-1999. The data collected during different days of every month have been pooled to work out an average figure for every month and also annual averages. The data on price of fuel and various other inputs have been collected periodically from the actual purchase records of individual enterprises as well as by making personal inquiry.

Secondary information from various sources has formed the basis of discussion on biology and bio-economics of fisheries. Secondary data on export quantity and prices collected from the publications of MPEDA and the rupee conversion rates of US $ collected from RBI publications have been used for analysis of trend of export and different relations.

Secondary data from All India Marine Fisheries Census (CMFRI, 1981) has formed the baseline data for craft and gear. The data on various types of mechanised fleet and gear have been obtained from different publications. CMFRI has updated the data on craft and gear by a rapid survey during 1998, which provided the latest inventory of the traditional and mechanized crafts and gears.

The National Marine Living Resource Data Centre (NMLRDC) of Central Marine Fisheries Research Institute has the spatial and temporal data on catch and effort of different types of gears. The gear-wise annual catch and effort data obtained from NMLRDC for the period 1990-1999 for the three maritime States of the upper East Coast, namely West Bengal, Orissa and Andhra Pradesh, have been used for various analyses on landing trends, exploitable potential, sustainable yield, optimum fleet size etc.

The exploratory survey data published by the Fishery Survey of India (FSI) and the data on potential resources revalidated by the Working Group (WG-I and WG-II) of experts are also used for the discussion on the resource potential. Information from various Government of India publications and other sources has also been used wherever necessary.

2.5. Methods and Tools of Analysis

A number of tools and methods of analysis have been used in this study for deriving various parameters. The choice of different statistical and economic methods and analytical tools has been made considering the various outcomes and information to be derived from the data and amenability of data to a given method. A broad outline of the methods and tools used in different sections of the thesis is provided below while details are provided in the respective Chapters.

2.5.1. Export Trend and Price Analysis

The ex-vessel price of different varieties of fish at Fisheries Harbour at Visakhapatnam during 1995 to 1999 (assumed to represent the price of marine fish for the whole of UEC) has been used to calculate the average price and three types of price indices detailed by Shepherd (1963). Trend analysis of marine products export has been carried out using the methods adopted by Biradar (1999).

2.5.2. Capacity Utilization

Estimation of capacity utilization of different gears has been made based on Peak-to-peak method (Greboval, 1999), which is suitable in cases where basic catch and aggregate fleet data are available (Pascoe *et al.*, 2004). Capacity utilization has been derived from the observed rate as a percentage of the expected rate as per the technology trend (TT). Further, the variable input utilization (VIU) has been calculated as per the formula given by FAO (1998) and Pascoe *et al.* (2004).

2.5.3. General Economic Analysis

The average costs and earnings of different types of vessels have been worked out on an annual basis for analysis. For this purpose, the various costs have been worked out as defined by FAO (1993). The economic performance of different class of fishing units has been evaluated based on revenue, profit, return on investment, cost per sea day, different financial ratios, break-even analysis, sensitivity analysis etc. In addition, factors of labour productivity and sustainability have also been worked out to understand the performance of the units.

2.5.4. Analysis of Landing Trends

For general analysis of the trend of landings, a method followed by Alagaraja *et al.* (1982) has been adopted for the convenience of comparison of the results with the historic data. Under this method, a macro-analytic approach, a percentage contribution of the different categories (pelagic, demersal, prawn, mechanised etc.) over years has been taken for detailed study. The components of the catch have been classified under pelagic and demersal groups following Jones and Banerji (1973).

2.5.5. Estimation of Exploitable Yield

In order to rationalise the optimum fishing effort along the upper East Coast, the yield that can be harvested has to be ascertained as accurately as possible. Since the available data and methods impose certain limitations on the precision of the estimates, a choice of three different methods has been adopted here for this purpose (Alagaraja, 1984, Anon 2000).

a) Maximum Contribution Approach (MCA)
b) Working Group 2000 Method
c) Relative Response Method

2.5.6. Estimation of MSY and Optimum Fleet

For estimation of maximum sustainable yield and optimum combination of fleet required to exploit the MSY, a macro-analytical approach recently suggested by Kurup and Devaraj (2000) was adopted in this study for its simplicity and suitability for the available data.

2.6. Organisation of the Study

The rest of the thesis is organised as follows. The next Chapter gives basic information on the biological aspects of fishery resources and environment necessary to understand the biological implications of application of technology in resource exploitation. The Chapter briefly dwells upon the marine fishery environment, population dynamics of fish, resource characteristics and bio-economic aspects. A brief description of the models of stock assessment is also presented in an appendix.

Estimates of potential resources form a basic input in planning fisheries development. The potential fishery resources of the Indian EEZ estimated by two different Working Groups of Experts are reviewed in the fourth Chapter. The additional harvestable yield and the current pattern of exploitation are also discussed in this Chapter. The fifth Chapter deals with the technology of fishing and provides an overview of fishing technology. The Chapter discusses the technological characteristics, limitations and capacity utilization of the different crafts and gear employed in artisanal and mechanized sector.

The sixth Chapter is devoted to study of marketing and price of fish, which decide the economic viability of exploitation. This Chapter provides an overview of factors of pricing and prices in export and domestic markets. The different trends in the export price and quantity, the indices of domestic fish price and relationship among prices of different items, average unit value realised, exchange rate of US $, and fuel price are also presented in this Chapter.

The seventh Chapter deals with the economics of operations of fishing units along the upper East Coast. The Chapter presents the different aspects of the economics of operations of seven different classes of fishing units using conventional analytical tools.

In the eighth Chapter the various issues of sustainable management of marine fisheries, the factors of unsustainability, approaches, methods etc. have been dealt with. This Chapter also presents the optimum combination of fleet for the upper East Coast and a framework for evolving strategies for rational exploitation and sustainable management of fisheries.

The ninth Chapter summarises the findings of the study and draws conclusions in the background of the objectives. The Chapter also addresses some of the policy challenges and options for sustainable development of marine fisheries along the upper East Coast of India. Bibliography, appendices and glossary are provided at the end.

CHAPTER – III

BIOLOGY AND BIO-ECONOMICS OF FISHERIES

CHAPTER – III

BIOLOGY AND BIO-ECONOMICS OF FISHERIES

3.1. Introduction

Understanding the biological aspects of the organism is a prerequisite for judicious exploitation and management of any living resource. Fishery biologists contribute mainly to two areas of the biology of the exploited resources. First they study the life cycle of the species and details of the environmental conditions needed for the different stages of the cycle. This is the basic output of all biological studies of organisms. Secondly biologists study the population dynamics, which is the basic input for formulating sustainable exploitation strategies for a given species. The integration of economic aspects into the biological models is a logical step to provide a framework for managerial decision-making.

In this Chapter, an overview of the important features of marine fishery environment is provided before elaborating the concepts of fish population dynamics. Subsequently the important characteristics of tropical marine fishery resources are discussed to provide an understanding of some of the issues in sustainable fisheries management.

The entire discussion in this Chapter is based on published information from various sources. An introduction of the biological aspects of exploited fish stocks is provided to better understand the interdisciplinary theme of this thesis. Further the elaboration is made on the salient concepts of fish population dynamics. The characteristics of the exploited tropical marine fisheries such as common property nature, bio-economics, multi-species and multi-gear exploitation are also discussed. The commonly used stock assessment models are detailed in Appendix-B.

3.2. Marine Fishery Environment

The oceans are dynamic environments supporting a variety of life forms, some of which are exploited for human use. The study of the interrelations among various biotic and abiotic factors in the sea has been a subject of great interest to researchers. The abiotic factors like temperature, light, salinity and nutrients basically decide the production, availability and abundance of different species of organisms at a given time and space. Currents and other movements of water masses also facilitate the spatial distribution of organisms. The influence of large-scale changes in marine environment like *El Niño* atmospheric phenomenon on fishery production is well known. The changes in production could be generally related in one way or other to the perturbations in natural environment or factors pertaining to exploitation.

The different life forms in the sea are linked together by various types of relationships and dependencies. The most important of the relationship is the intricate food web including the predator-prey relation among different life forms. The starting point of the food web is the microscopic plants, the phytoplankton, which capture the sunlight and synthesize food from carbon dioxide and water. The primary (phytoplankton) production in a given area decides the production at different levels above in the food pyramid. An efficiency factor of 0.1 is conventionally assumed from one trophic level to the other. The production of fish depends on the primary, secondary and benthic production of a given area. It is possible to derive indirectly the fishery potential of a given area from the estimates of production at different trophic levels.

Depending on the requirements of a particular stage in the life cycle, fish and other organisms move about from one region (habitat) to another. This is apart from the diurnal migration of organisms observed in all water bodies. The prevailing circulation and currents of the sea play an important role in the transport or migration of different organisms. The purpose of migration of fish may be for feeding, breeding or avoiding adverse conditions. For example, the adult penaeid prawns grow and breed in the sea, the larvae migrate to the nursery grounds in coastal estuaries and backwaters again to migrate back to sea as sub-adults. The large-scale migrations of salmonids in temperate countries of the Northern Hemisphere, freshwater eel in Europe and hilsa shad in Indian waters are best examples for the extensive migration of fish between river and sea. The over-exploitation of theses species at any point in the path of migration or reduction in stock due to some adverse environmental conditions will result in the collapse of the fishery in subsequent periods. Therefore understanding the biological and environmental conditions necessary for survival and sustenance of different species of fish is a prerequisite for their judicious exploitation. Detailed treatment of some of these subjects could be found in various publications (Steele, 1970; Cushing, 1975; Jones 1982; Longhurst and Pauly, 1987).

3.3. Concepts of Population Dynamics

In order to discuss population dynamics, it is instructive to consider fish population or stock as a simple biological system. There are several processes within the fish stock controlling its number (density) and weight (biomass). The numbers are increased by the reproduction of adult fish and young ones are added or recruited into the stock. In addition, individual fish grow in body weight and contribute to increase in biomass of the stock. Concurrently the number and weight of the fish stock is reduced by natural mortality caused by predation, disease, senility etc. in an unexploited stock. In an exploited stock, however, fishing becomes an important factor contributing to the mortality in the stock. It is appropriate to discuss the important aspects of growth, recruitment and mortality for a better understanding of the population dynamics of fish.

3.3.1. Growth in Fish

The most important aspects to be considered for studying the population dynamics of a species are the growth, mortality and recruitment. The estimation of different parameters of growth, mortality and recruitment involves varying degrees of difficulty. While adequate methods exist for making reasonable estimates of some parameters, some others are difficult to estimate.

Growth may be described as changes in the body length, width or any other linear dimension or weight. Length (standard length, total length or fork length) is most often used, as it is the easiest to measure onboard, at the field and in the laboratory. However, weight measurements are also required for some purposes such as calculation of yield. A convenient method is to determine a relationship between length and weight or other dimensions over a wide size range of individuals for use in different applications. The relationship between length (L) and weight (W) in fishes is observed to follow the power curve equation:

$$W = aL^b$$

Generally the values of a and b are derived by fitting a linear regression of the of logarithms of length and weight data in the form:

$$\ln W = \ln a + b \ln(L)$$

If an animal growing *isometrically* (increasing in all dimensions at the same rate) doubles in length, its weight will increase by the power of three (i.e. in relation to the increase in volume). Thus there is a cubic relationship between length and weight in which case the coefficient $b = 3$. Generally, the value of b may be more or less than three, when the growth is termed as *allometric*.

Provided the age of fish can be determined, the estimation of parameters of growth is straightforward. The main uncertainty lies in the choice of an appropriate growth equation. Several models have been used to express growth using simple mathematical equations (Allen, 1971). The need to simplify the methods of estimation in the past has led to the acceptance of exponential and von Bertalanffy forms of growth functions as most useful. Of these two, the latter has come to stay as the conventional form possibly because of its incorporation in to fishery yield equations by Beverton and Holt (1957). The von Bertalanffy equation in term of length is:

$$L_t = L_\infty[1 - e^{-k(t-t_0)}]$$

Where L_t is the length at age t, L_∞ is the theoretical maximum (or asymptotic) length that the species would attain if it lived indefinitely and K is the growth coefficient, which is a measure of the rate at which maximum size is attained. As the animal is unlikely to grow according to the above equation throughout its life span, particularly in pre-adult stages, the curve often cuts the X-axis at a value less than zero. Hence t_0, the theoretical age at zero length often has a small negative value. The von Bertalanffy equation in terms of weight (assuming isometric growth) is given below.

$$W_t = W_\infty[1 - e^{-k(t-t_0)}]^3$$

There are various methods of estimating the growth parameters from different types of data. In tropical fisheries, methods based on length frequency data are commonly used.

3.3.2. Reproduction and Recruitment.

Reproduction and recruitment are two major events in the life history of an organism. In some species, these events involve movement or migration between different areas or habitats. In fisheries studies, recruitment refers to either the addition of new fish to the 'vulnerable' population by growth from among smaller size categories (Ricker, 1975) or the entrance of individuals to the area where fishing occurs (Beverton and Holt, 1957). This last definition is perhaps more suited to fish population dynamics studies as it distinguishes nursery and breeding grounds from the fishing grounds.

The times of the year and mean length at which spawning and recruitment occur are two important aspects of interest to the fishery scientists. Researchers devote attention to estimate the mean length at recruitment (L_r), the mean length at first capture (L_c) and the mean length at sexual maturity (L_m). If growth parameters are known, these lengths can be converted to the corresponding mean ages t_r, t_c and t_m using the inverse of the growth equation. The length at sexual maturity and length at first capture are important factors to be considered while deciding the types of gear for exploitation.

Another important aspect pertaining to the recruitment is the stock recruitment relationship. Generally it is expected that when stock size is large, recruitment will be high and a higher recruitment will result in a larger stock size. Invariably, these general rules are disturbed by many factors external to the stock. Ultimately, the recruitment does depend on stock size in all species and a graph relating recruitment to stock size will always pass through the origin. Several models have been suggested to describe the relationship (Beverton and Holt, 1957; Ricker, 1954).

3.3.3. Survival and Mortality

In the marine environment, many forces act to reduce the chances of survival of individuals in a population. These include adverse conditions like lack of food, competition and most importantly, predation. The loss of individuals in a population through death can be discussed in terms of percentage of individuals that survive (survival rate) over a particular time interval or percentage that die (mortality rate). Rather than using percentage, it is a convention to consider the instantaneous mortality rate Z which applies over a very short interval of time, dt. The instantaneous rate of change in numbers of fish (dN / dt) is proportional to the number N_t present at time t.

$$dN /dt = Z N_t$$

Where Z is the instantaneous mortality coefficient. This equation can be rearranged and integrated to give the numbers from $t = 0$ to $t = t_1$ and thereby the exponential decay expression of survival rate;

$$S = N_t / N_0 = \exp [-Zt]$$

Where N_0 is the initial number of individuals at time $t = 0$ and N_t is the number remaining at time t. The number of individuals surviving over time is in the form of a negative exponential curve.

In an exploited fishery it is necessary to distinguish between mortalities caused by fishing and those caused by natural phenomena. The total mortality rate (Z) is the sum of the instantaneous rate of fishing mortality (F) caused by fishing operations and the instantaneous rate of natural mortality (M), which include death caused by other factors. Thus,

$$Z = F+M$$

In an unexploited fishery, $F = 0$ and therefore, $Z = M$. However, in an exploited fish stock, numbers surviving will tend to decline exponentially with time or age according to the sum of instantaneous rate of fishing mortality and the instantaneous rate of natural mortality. Thus,

$$N_t / N_0 = \exp[-(F+M)]$$

or

$$N_t = N_0 \exp[-(F+M)]$$

Reliable methods are available for estimating the instantaneous total mortality rate Z, the most common one being age-structured catch curve method. Some methods are also available for estimation of natural mortality. Once these two parameters are arrived at the other can be easily deducted.

3.3.4. Exploitation Levels

In a fish stock, which is unexploited or exploited at lower levels, the losses through mortality are more or less balanced by gains from recruitment. Generally, the stock abundance fluctuates around a mean level. If an exploited fishery is to sustain, the natural mortality and fishing mortality together must be balancing the annual addition by recruitment. If the exploitation is high, the number of adult fish may be reduced to a low level where reproduction is unable to replace the numbers lost. If the number of fish caught becomes too large, recruitment will be too small to maintain stock size and the number of fish will decrease. If the adult fishes are reduced in number to the extent that recruits produced are insufficient to maintain the population, it is termed as *recruitment overfishing*. If the young fishes recruited into the fishery are harvested at relatively smaller size before they attain optimum marketable size, it is considered as *growth overfishing*. Thus the sustainable and rational exploitation of fishery resources implies harvesting of optimum number of fish without adversely affecting the stock recruitment and allowing the smaller individuals to achieve optimum growth.

Assessment of fish stocks is the first step to determine the required level of fishing effort for harvesting the maximum sustainable yield (MSY). However, fish stocks differ from other living resources in three main aspects. First these stocks do not come under visual horizon for direct evaluation of their sizes and other characteristics. Variability in their distribution in time and space add to the complexity and dimensions, not encountered in the assessment of other resources. Finally fish stocks, particularly the exploited stocks, are affected by fishery dependent and fishery independent factors. While fishery dependent factors are controllable, the fishery independent factors are uncontrollable. Thus models to study the fish stocks should take into account at least three aspects namely the size of the stock, present level of exploitation and effect of fishery independent factors. The dimensions of parametric space expected in such models incorporating all the above aspects become very large and the whole exercise becomes a formidable task. Nevertheless, mathematical models suited to fish stock assessment satisfying some of the requirements indicated above have been developed and successfully used to offer suitable management measures (See Appendix-B). For unit stock assessments assuming equilibrium conditions, the variability due to fishery independent factors are safely ignored.

3.4. Resource Characteristics

The exploited marine fishery resources are different in many ways from other natural resources. Understanding the characteristics of these resources is essential for their sustainable exploitation and management. Some important features of the marine fishery resources, especially those of tropical seas, are discussed below.

3.4.1. Common Property Resource

Common property resources (CPR) can be broadly defined as non-exclusive resources to which the rights of use are distributed among a number of owners. Marine fishery resources all over the world are typical examples exhibiting the true dynamics of CPR. The common property marine fisheries has figured in a recent work on Indian CPRs (Kadekodi, 2004). In a virgin fishery, the first fishing unit entering to exploit the resources would be rewarded with a high return per unit of effort. This would give incentive for the fisherman to introduce another fishing unit. Attracted by the profitable venture of this pioneer fisherman, neighbours would also add their own units one after the other since there are no restrictions. Thus the addition will go on so long as there is some resource rent to be shared. Ultimately, the exploitation will become nonviable to most of the units and some of them would withdraw from the fishing operations. This process of withdrawal may help the stocks to recover at some point of time and again provide some resource rent, further attracting investment and so on. Thus in an open access fishery, the stocks will be overfished and fishermen will ever remain impoverished. In other words the situation would result in the so-called 'tragedy of the common' (Hardin, 1968).

Various aspects of the so-called 'over-fishing problem' have been discussed by some early workers (Russell, 1931; Graham, 1952). A sound theoretical explanation of the persistent low income of the fishermen was provided by Gordon's (1954) theory of the 'common property' fishery, which has since become a classic. An examination of the salient aspects of Gordon's work would be worthwhile since it provides the theoretical basis for bio-economic analysis of open access fisheries. The basis of many of the arguments for 'effort control measures' in fisheries management discussed in this thesis also rests heavily on that theory.

3.4.2. Gordon- Schaefer Model

Gordon's analysis was implicitly based on a simple yield-effort curve (Schaefer, 1954) employed by fishery biologists (Fig.3.1a). The bell shaped curve depicts yield or annual catch Y as a function of fishing effort F. The term F refers to the level of fishing intensity exerted on a given stock of fish by fishermen. The yield Y refers to the annual catch that can be sustained over long run if a fixed level of effort F is maintained. Thus the yield really refers to *sustainable yield* and the figure gives a static or equilibrium view of the fishery, which is said to be a serious limitation of the Gordon's model. Clark (1985) has attempted to deal with this limitation in Gordon's model by incorporating dynamic functions.

As fishing effort increases from lower levels, the yield also increases to peak at a level referred to as the *maximum sustainable yield* (MSY). With further increase in effort, the yields decline and at sufficiently high-sustained effort levels, yield theoretically falls to zero. When the yield falls below MSY, *Biological overfishing* is said to have taken place. At these levels of exploitation, the fish stock is reduced to a level at which productivity begins to decline.

To continue with the Gordon-Schaefer model, let p denote the price of fish received by the fishermen and let c denote the cost of applying one unit of effort, both p and c are assumed as constants. The cost here implies the opportunity cost, that means the total cost of resources employed in pursuing the activity, as considered in

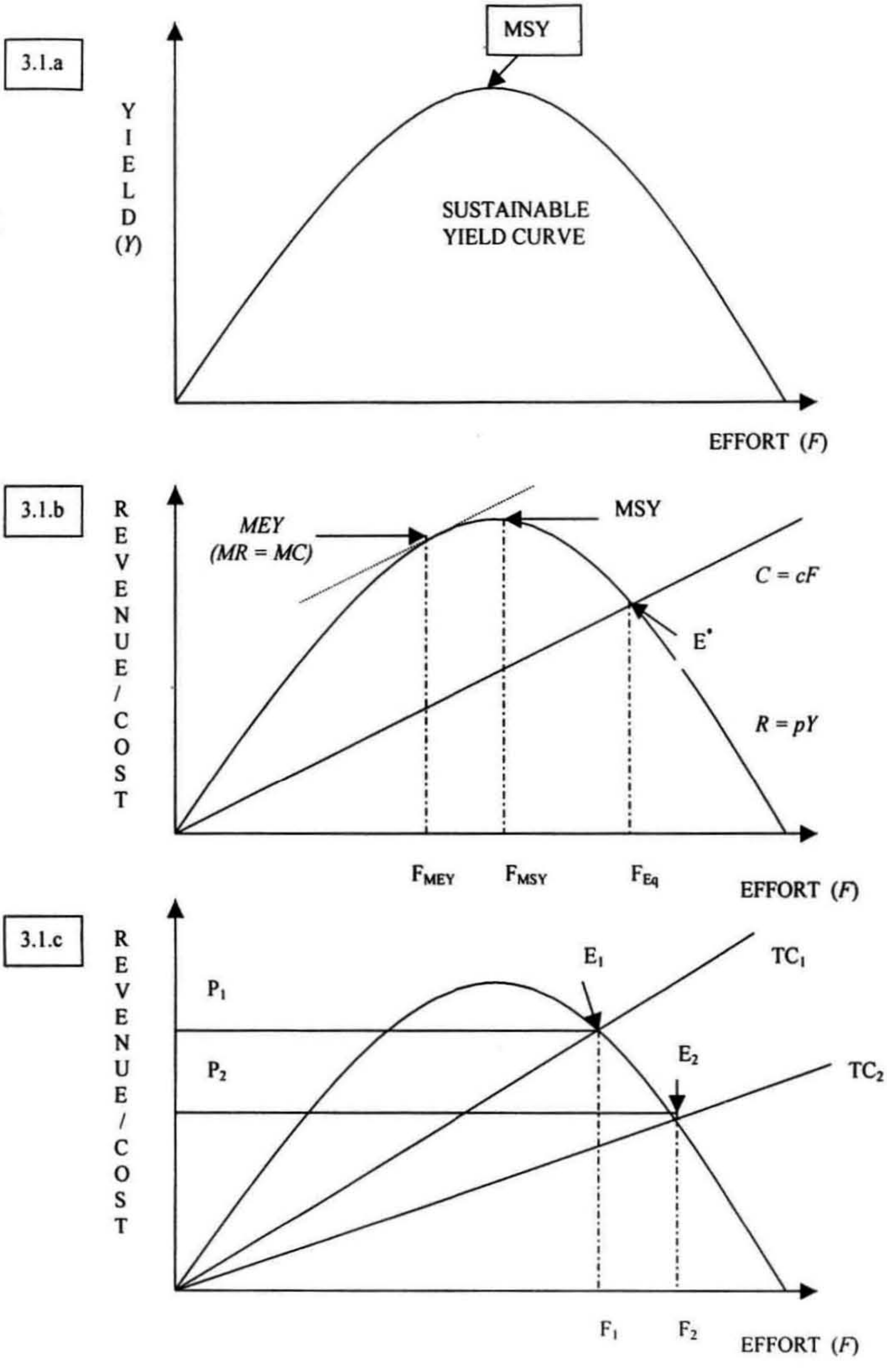

Figure 3.1. Gordon-Schaefer bio-economic model in open access fisheries

economic analysis. The revenue curve is represented by the equation $R = pY$, where Y is the yield curve in figure. 3.1a. The straight-line cost curves have the equation $C = cF$, cost assumed proportional to fishing effort. In an unregulated open access (common property) fishery, effort will expand to the level F_{Eq} at which the total revenue equals total cost (point E*). This level of effort represents and equilibrium in which the economic forces affecting fishermen and the forces of biological productivity of the resource are in balance.

For the given linear cost function, the difference between cost and revenue lines (the profit or resource rent) gradually increases as more and more effort is applied until it reaches the *maximum economic yield* (MEY) at an effort F_{MEY} (Figure.3.1.b). From the economic point of view, this is the point at which, the marginal revenue equals marginal cost ($MR=MC$). The level of effort F_{MSY} yields the maximum total yield (MSY), though the average revenue at this point would be less than that at MEY. However, in an unrestricted fishery, the existence of profits attracts further investments, which push the effort up to or beyond F_{MSY}. In the long run, the fishery stabilizes at a point of equilibrium E* where the vessels break-even and no more profits remain to be shared. In the economic terminology, this is the point at which marginal revenue becomes zero (MR= 0). Under private ownership, the owner would restrict the effort at F_{MEY} because profit maximization is attained at that level. From the biological point of view, the MSY is desirable because it maximizes the catch without damaging the stock.

The effect of technological changes may have a favourable impact on the cost of operation of fishing vessels (Fig.3.1.c). A 'technology creep' may increase the effective fishing effort without increasing the cost. In effect this would push the total cost line TC_1 to TC_2. A subsidy on operational input such as HSD will also produce the same effect on the cost line. The shift in cost line pushes the equilibrium from point E_1 to E_2 because there appears a profit of magnitude $P_1 - P_2$, further attracting investment. In the long run this increased effort would further push the stock down to dangerous levels.

A pertinent point to be borne in mind is that the quantum or level of fishing effort required to exploit the given resources changes with the objective of exploitation. Two broad objectives namely the *Maximum Sustainable Yield* and *Maximum Economic Yield* can be theoretically identified. The former is the biological optimum, the maximum quantity of fish, which can be sustained from a fishery without affecting the stock in the long run. The latter connotes the level at which the yield per unit effort in terms of revenue is maximum for a given technology. At MEY, though the operation is economically most efficient, there is still some more fish that could be caught. In view of providing the cheap and much needed protein food to the people, full exploitation of the resource becomes the main objective in the low-income food deficit countries (LIFDCs).

3.4.3. Multi-species Multi-gear Fishery

Tropical marine fishery resources differ from their temperate counterparts in many aspects. Unlike the temperate resources, the tropical species are generally fast-growing, short-lived and spawn continuously (fractionally). The most striking feature of the tropical marine fisheries is the multitude of species contributing to the fishery. It is estimated that the total number of fish species in the Indo-Pacific Area is as high as 6,000 - 7,000 (Carcasson, 1977). In general, a single haul with 50 or more species is very common. A second feature of the tropical stocks is that most of the component species are small sized (Pauly, 1979). The third important feature is that the peak occurrence of most constituent species is in shallow waters. Finally the species assemblages in the region of which the stocks are a part are probably peak communities evolved out of long common history in an extremely stable environment. Tropical marine communities are characterized by predominance of a particular species, adapted to a certain set of stable environmental factors and specific predator-prey relational advantages. Unlike the high latitude fisheries multiple stock fishery resources are reported to form a robust system and can tolerate wide variations in fishing mortality without any adverse effects (Garrod, 1973).

In most cases a fleet exploit several stocks and several fleets compete to exploit the same resources. In such situations we encounter three main types of interactions between components of multispecies/multifleet system (Sparre *et al.*, 1989).

i) *Biological interaction* means the interaction between fish stocks (and within fish stocks) caused by predation and food competition.

ii) *Economic interaction* means the competition between fleets (e.g. between industrial fishery and artisanal fishery). The more one fleet catches a limited resource, the less will be available to its competitors.

iii) *Technical interaction* means that the fishery of one stock creates fishing mortality on other stocks because the fishery is either a multispecies fishery or because of inevitable bycatches.

The multi-species nature makes the development and application of stock assessment of models in tropical fisheries difficult. Different workers have suggested various approaches to models taking interactions into account. The majority of them are extensions of single species, single fleet models. FAO (1978), Pope (1979 and 1980) and Pauly and Murphy (1982) reviewed the multi-species multi-fleet fisheries assessment with special reference to tropics. In the Indian fisheries, the exploitation of multi-species fishery being done by a multitude of fleet and gears, it is all the more difficult to undertake such exercises.

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CHAPTER – IV

RESOURCE POTENTIAL AND EXPLOITATION

CHAPTER – IV

RESOURCE POTENTIAL AND EXPLOITATION

4.1. Introduction

India's declaration of the 200 nautical miles Exclusive Economic Zone (EEZ) in 1976 bestowed on her the right and responsibility for exploitation and conservation of marine living and non-living resources in an extensive area of 2.02 million km^2 of the seas around her (Khan, 1977). As information on the fishery potential of the EEZ became necessary for planning marine fisheries development and formulating exploitation and management strategies, George *et al.* (1977) in a pioneering attempt estimated the potential yield of the Indian EEZ to be 4.47 million t based on available information. This formed the basis for marine fisheries development planning in the subsequent years.

Rapid developments that took place in the industry during nineteen seventies and eighties changed the exploitation scenario. Expansion of all types of fleets, motorisation, improved material and efficient design of gears etc. together with changing pattern of fishing increased the pressure on the coastal resources of the Indian EEZ. To relieve the pressure on the coastal resources, diversification in fishing to exploit offshore and deep-sea resources was felt essential. Parallel to initiation of policies, Government of India constituted a Working Group (WG-I) of experts for revalidation of resources of the Indian EEZ based on the latest exploratory and exploitation data. The report of the WG-1 (Anon., 1991) detailed the qualitative and quantitative potential in space of the fishery resources of the Indian EEZ and put the total potential as 3.9 million tonnes, similar to that worked out by Sudarsan *et al.* (1990).

Deep-sea fishing policy initiatives of the Government did not yield the expected results for various reasons. During the nineties, the resources in the inshore waters were further subjected to increased fishing pressure resulting in changes in the species and size composition of the catch. In the context of these changes and the long-felt need to diversify into other resources of deeper water such as the oceanic tuna, another exercise of revalidation was conducted recently. Considering the decline in the abundance of certain groups and increase in landings of certain other groups the WG-II revalidated potential resource as 3.93 million tonnes, marginally higher than the earlier estimate (Anon., 2000).

A brief review of the estimated potential and the trend of exploitation will be appropriate to provide a better perspective of the opportunities and challenges in resource exploitation. In this Chapter, the spatial distribution of the estimated potential of major fishery resources of the EEZ is examined based on the published reports. Further, the trend of landings along the upper East Coast is analyzed and the exploitable potential is estimated applying different methods.

4.2. Estimation Techniques

The discussion on fishery potential of the EEZ was made on the basis of published information mainly that by Sudarsan (1990) and the reports of the Working Groups (Anon., 1991 and 2000). In order to understand the state of resource exploitation along the upper East Coast, the yield that can be harvested has to be ascertained with reasonable accurately. Since the available data impose certain limitations on the choice of method of estimation, three different methods applicable to the data have been adopted here. The advantages of multi-method approaches are asserted on account of the capacity to undertake triangulation- the use of a series of complementary methods - in order to gain a deeper insight into a problem (Hoggart *et al.*, 2002).

4.2.1. Maximum Contribution Approach (MCA)

In the absence of any perceptible interaction between the groups and gears, MCA will indicate the level of exploitable fishery resources of a given region. Under this procedure, data on group-wise landings for the period 1990-99 have been considered. The maximum estimate for each group during this period was noted and such yields have been added to arrive at the maximum yield from the region. The maximum total landings recorded in the three States and the upper East Coast have also been provided for comparison.

4.2.2. Working Group (WG) Method

Micro level studies require enormous data, which are not readily available from any source. One of the main hurdles in applying a micro level analysis is the standardization of fishing effort. Conventionally the method used is to identify a standard gear in respect of the fish that is studied. Thus for a given species of fish, let C be the total catch and let C_s be the catch by the standard gear and F_s be the effort by the standard gear. Then let $U_s = C_s / F_s$ be the catch per unit effort (CPUE) by standard gear. Then effective effort for total catch is found by the formula:

$$F = C/U_s$$

This method does not differentiate the efficiencies of different gears in exploiting the same stock and often lead to overestimation of the effective effort. This is overcome to a certain extent as follows:

Let C_i (i = 1, 2, 3, .. k) be the catch of a given species by i^{th} gear, f_i be the corresponding effort by the i^{th} gear and $U_i = C_i / f_i$ be the corresponding catch per unit effort. Then effective CPUE of this species is obtained as:

$$U_s = \sum E_i x U_i$$

Where $E_i = C_i / C$ (E_i is the score of efficiency of the i^{th} gear in exploiting the given species. The standard effort for the species is $F_s = C / U_s$. Then the functional relationship between C / F and F is fitted as $C / F = a - bF$. Then an estimate of MEY, the *Maximum Expected Yield* following the usual method is obtained as:

$$MEY = a2 / (4b)$$

The MEYs have been estimated for different groups for the three maritime states of UEC and pooled to obtain the total for the region using the data for the period 1990-1999.

4.2.3. Relative Response Method

This model uses successive year's catches to predict the maximum catch that the fishery can sustain. There are three assumptions (Alagaraja, 1984) for success of this model:

a) Various types of gears that exploit stocks existing in a particular area are not species specific. This implies that the effect of fishing a mixture of stocks by these gears is proportional to the relative abundance of stocks in the mixture.

b) Fishing effort is increased over a period of time till the optimum level is achieved.

c) When the effort is increased the catches also increase till maximum level is reached but the rate of change increases first then decreases and finally reaches zero.

In tropical multi-species multi-gear fisheries, where evaluation of effective effort poses problems, this model is particularly useful. The model is:

$$C_t - C_{t-1} = f(C_{t-1}) \qquad (1)$$

A simple version of the above is a linear relationship between the successive catches, given as:

$$C_{t+1} = a + b\, C_t \qquad (2)$$

In the progressive fishery, the level of maximum catch can be predicted and suitable management measure could be suggested in advance to get sustainable yield from the fishery. The equation (1) is the same form as the well-known von Bertalanffy's growth model. Hence in the notation of equation (1),

$$C_{t+1} = C_{max}\,(1-e^{-k}) + C_t\, e^{-k} \qquad (3)$$

And

$$C_{max} = a\,/\,(1-b) \qquad (4)$$

This method has been applied to the data for the period 1975-1999.

4.3. Estimated Potential of the EEZ

Considering the wider boundaries of distribution of fish stocks, the estimates of potential resources of the Indian EEZ are best represented region-wise. The resources are conveniently grouped as demersal, pelagic and oceanic. The Report of the first Working Group of Experts on revalidation of the potential marine resources of the EEZ (WG-I) contain depth-wise, region-wise details of the estimated potential of different groups. Presentation of the depth-wise data would give an idea of the relative abundance of resources in space and would facilitate understanding the current pattern of exploitation as well as the techno-economics of exploitation. Though the upper East Coast is the area relevant to the present study, data pertaining to other areas is also provided to get a relative picture of the potential. The oceanic resources shall not be discussed here as they are beyond the exploited area of the fishing units under study.

4.3.1. The Demersal Resources

The total demersal fisheries potential of the Indian EEZ has estimated as 1.93 million t of which 1.28 million t are within 50-m depth zone of the EEZ. Thus the estimated potential of demersal stocks in the deeper waters (>50m) works out to be 0.65 million t (Table - 4.1). The 200-300/500 m depth zone is comparatively poor in resources except perhaps in the Southwest coast. The Northwest coast is richest both in 50-100m as well as 100-200m depth zones. On the other hand, the lower East Coast is poorest in these two depth zones. As regard to the total figures, the northwest coast tops in potential followed by upper East Coast. Apparently there is steep gradient in the potential from shallow waters to deeper waters.

4.3.2. The Pelagic Resources

Pelagic resources contribute to about 47 percent of the country's fish landings and their exploitation is mainly confined to the near-shore waters. The estimated potential of pelagic resources over the continental shelf (0-200 m) is 1.74 million t (Table - 4.2.). Of this about 58 percent are on the West Coast, 15 percent on the

Table - 4.1. The region-wise, depth-wise estimated potential (thousand tonnes) demersal resources of Indian EEZ based on trawl surveys.

REGION	DEPTH ZONE (m)				TOTAL
	0-50	50 – 100	100 –200	200 -300/500*	
North-west Coast	535.7	274.3	104.3	0.4	**914.7**
South-west Coast	223.5	63.2	29.1	20.0	**335.8**
Lower East Coast	188.3	13.4	23.4	3.1	**228.2**
Upper East Coast	309.7	72.9	44.5	0.8	**427.9**
Andaman Sea	22.5				**22.5**
300 – 500 m **				4.0	**4.0**
TOTAL	**1279.7**	**423.8**	**201.3**	**28.3**	**1933.1**

*Source: Sudarsan et al.(1990), *Includes resources up to 500 m depth between Lat. 8°-10° N along west coast and up to 300 m in other regions, ** Except Lat. 8°-10° N along west coast.*

Table - 4.2. Region-wise, depth-wise estimated potential (thousand tonnes) pelagic resources of Indian EEZ over the continental shelf (0-200 m).

REGION	DEPTH ZONE (m)			TOTAL
	0 –50	50 – 100	100 –200	
North-west Coast	331	161	27	**519**
South-west Coast	342	183	62	**587**
Lower East Coast	213	32	29	**274**
Upper East Coast	114	25	21	**160**
Lakshadweep				**63**
Andaman & Nicobar				**139**
TOTAL	**1000**	**401**	**139**	**1742**

Source: Sudarsan et al. (1990)

East Coast, eight percent in the Lakshadweep Sea and 19 percent in the Andaman and Nicobar waters.

4.3.3. Second Revalidation

The second Working Group (WG-II) revalidated the resource potential as 3.93 million t consisting of 2.02 million t of demersal 1.67 million t of pelagic and 0.24 million t of oceanic resources (Table - 4.3). The potential estimates of demersal resources have included for the first time 0.22 million t of bivalves and gastropods in the estimate. Estimates were provided for as many as 68 groups.

The recent average annual yield (during 1993-98) of 2.45 million t and the changes in the landing pattern were considered while the estimated potential was revalidated as 3.93 million t. Additional yield of 1.48 million t above the present average yield could be harvested from the Indian EEZ, provided the techno-economics permit the same. The component of bivalves and gastropods in the revalidated estimates to the extent of 0.2 million t is partially harvested as subsistence activity by the artisanal sector.

4.4. Pattern of Exploitation

The changes that took place in the marine fisheries sector along the upper East Coast during the last quarter of a century were significant. The number of vessels in all categories increased with resultant changes in the area and extent of operation. Consequent changes in the production were also noticed during this period. The pattern of exploitation as reflected in the landings along the three maritime states is worth examining in this context.

Table - 4.3. Revalidated region-wise potential, present average yield and additional harvestable yield (thousand tonnes) of different categories of resources.

Resources	Region NE	SE	SW	NW	Total Potential Yield	Present Average Yield *	Additional Yield
Pelagic finfish	81.3	419.2	751.9	421.2	1673.5	1221.9	451.6
Demersal finfish	82.7	330.9	307.9	479.0	1200.5	1229.9	787.2
Crustaceans	11.8	66.1	159.8	253.3	491.0		
Cephalopods	0.5	13.6	43.0	44.1	101.3		
Bivalves and Gastropods	0	122.9	91.2	10.1	224.3		
Oceanic					243.8		243.8
Total	176.3	952.7	1353.8	1207.8	3934.4	2451.8#	1482.6

**Average of 1993-98. # excluding molluscs and cephalopods*
Source: Anon., 2000

4.4.1. Trend of Landings Along the Upper East Coast

For general analysis of the trend of landings, a method followed by Alagaraja *et al.* (1982) has been adopted for the convenience of comparison of the results with that of the earlier work. Under this method, a macro-analytic approach, percentage contributions of the different categories (pelagic, demersal, prawn, mechanized etc.) over the years have been taken for detailed study. For this purpose the following assumptions have been made:

i) Equilibrium is maintained over the years in the fish stocks exploited in Indian coastal waters.

ii) Fishery independent factors will have more or less uniform effect on the availability of exploited species.

iii) Change in the pattern and intensity of fishing, such as introduction of mechanized crafts etc. will also have uniform effect on the exploited fisheries.

The data on marine fish landings for the period 1990-1999 from NMLRDC of CMFRI, collected using a well-designed systematic, stratified, multistage random sampling have been used for this analysis. The components of the catch have been classified under pelagic and demersal following Jones and Banerji (1973). Landings of the mechanized boats other than the large trawlers (whose catch estimates are not available) have been considered for the landings under mechanized sector. Since prawns are heavily exploited both by mechanised and traditional units, this fishery has also been considered as one of the groups. Under the assumptions made earlier, differences in the percentage distribution of three sectors over the years in the maritime states may indicate the effect of fishery dependent and independent factors. To study the overall pattern of distribution, ANOVA on percentage values transformed to arc sine values, has been considered. Since ANOVA may fail to indicate the presence of any trends, owing to wide fluctuations inherent with capture fisheries, rank correlation analysis has also been taken up.

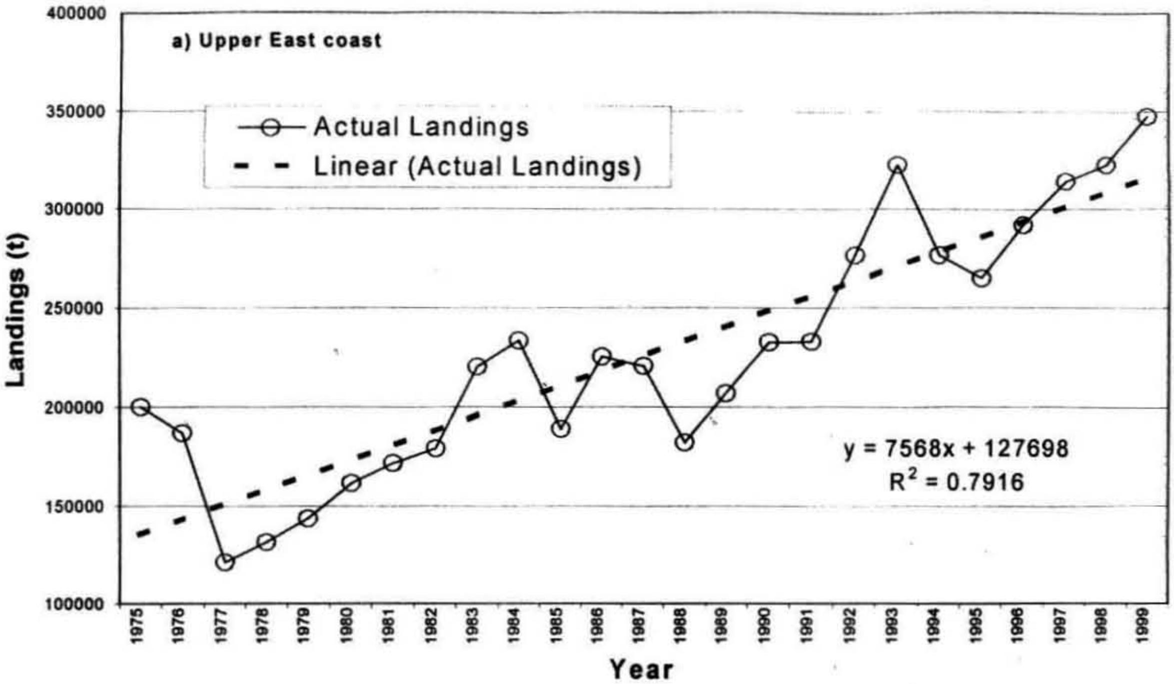
The marine fish production in the three states of the upper East Coast during the 25 years showed wide fluctuations (CV=27.69) between 121094 t (1977) and 347140 t (1999) with an average of 226083 t. The annual production showed a steady increasing trend towards three lakh tonnes during recent years (Fig. 4.1a).

The marine fish production in West Bengal varied between 5266 t (1977) and 91969 t (1993) with widest fluctuations (CV=68.03) during 1975-99. The annual average of production during this period was 41035 t. The trend of production indicated stabilization between 70 and 80 thousand t during recent years (Fig. 4.1b).

In Orissa, the marine fish production during 1975-99 varied between 15072 t (1977) and 64736 t (1990) with wide fluctuations (CV=27.41). The annual average of production during this period was 44307 t. The trend of production has come to fluctuate between 40 and 60 thousand tonnes in recent years (Fig. 4.2a).

The marine fish production in Andhra Pradesh during 1975-99 varied between 82,116 t (1978) and 233,255 t (1999) with less wide fluctuations (CV=24.10) compared to the other two States. The annual average of production during this period was 140,740 t. The production trend showed a steady increase during the period, reaching over 2 lakh t in recent years (Fig. 4.2b).

As detailed in the section on methods, the percentage contributions of mechanized, prawns, demersal and pelagic landings over the years 1990-1999 in the three maritime States of the upper East Coast were worked out and are presented below.



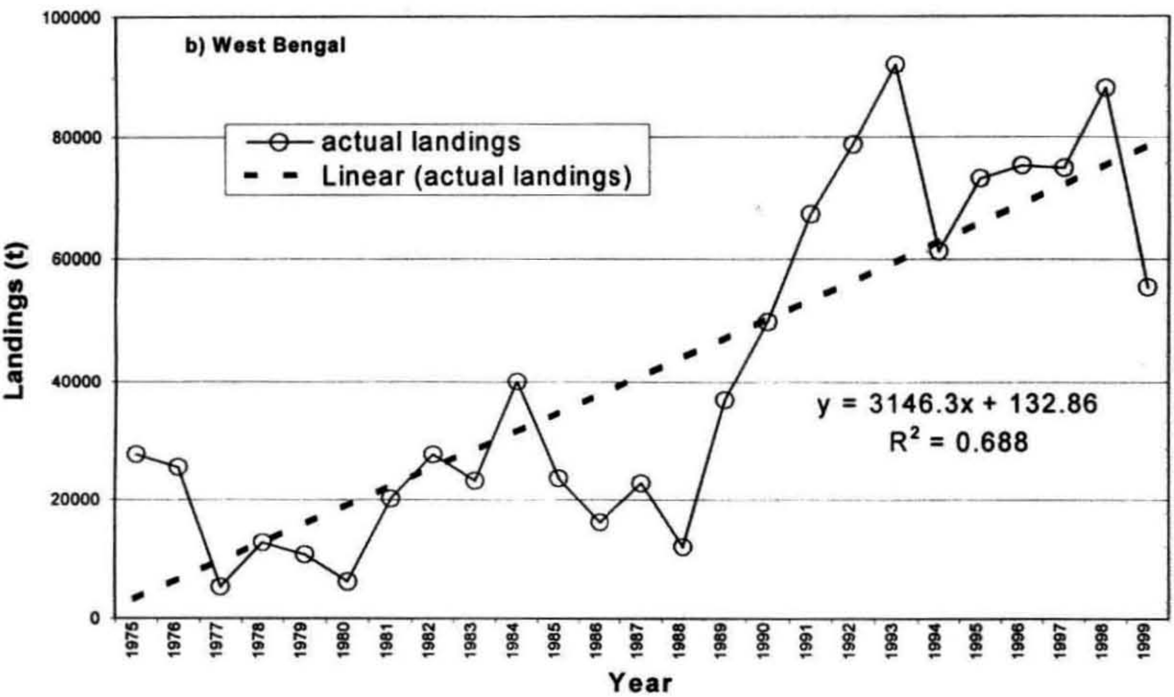
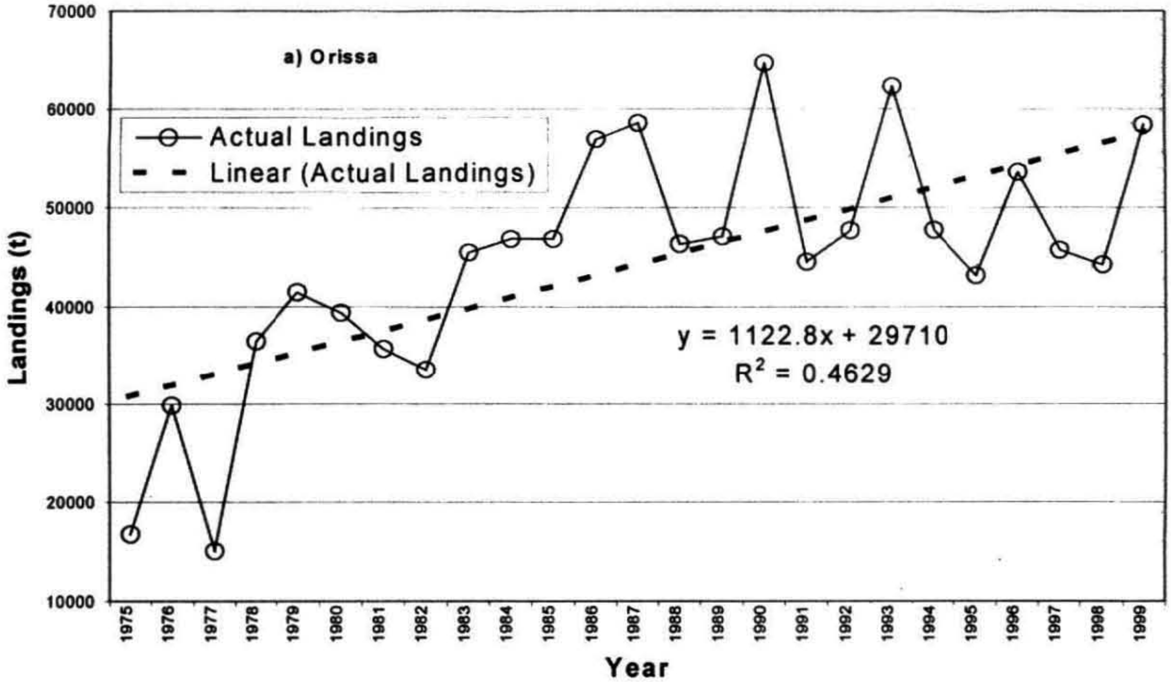


Figure. 4.1. Trend of marine landings in a) the upper East Coast (total of three maritime States) and b) West Bengal during-1975-1999.



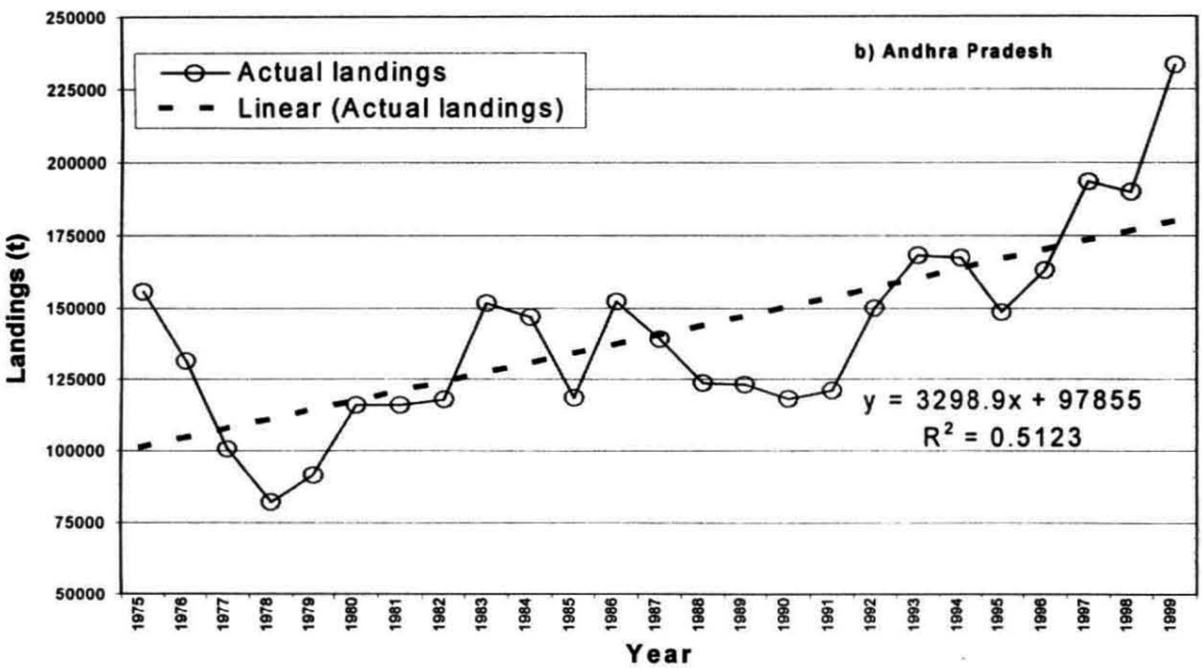


Figure. 4.2. Trend of marine landings in a) Orissa and b) Andhra Pradesh during 1975-1999

The percentage contribution of prawns to the total landings of upper east coast (three States) during 1990 – 1999 varied between 7 percent (1992) and 12 percent (1999). During this period the mechanised sector's contribution ranged from 49 percent (1999) to 66 percent (1991). The contribution of pelagic groups was showing only moderate range between 51 percent (1990) and 60 percent (1997). Demersal landings, on the other hand, showed contributions ranging from 25 percent (1998) to 35 percent during this period. While there was a moderate increasing trend in the contribution of prawns during this period, no such trend was visible in the case of mechanised sector. Landings of pelagic groups showed no discernible trend during this period whereas a slight decreasing trend could be noticed in the case of demersal groups' contribution.

In West Bengal the share of prawns in the total landings varied from 4 percent (1991) to 14 percent (1999) showing an over all improvement over the years. While the share of mechanised sector varied between 67 percent (1999) and 96 percent (1997), pelagic groups accounted for 47 percent (1999) and 70 percent (1992 and 1993). Demersal groups, on the other hand, contributed 18 percent (1990 and 1993) to 32 percent (1996). A comparison with the past records (Alagaraja *et al.*, 1982) indicated some marked changes. The percentage contribution of prawn fishery showed a significant decline as compared to the 23 percent recorded during 1973. The contribution from mechanized sector, which was not significant during 1969-77, has come to contribute to the bulk of the landings.

In Orissa, the contribution of prawns to the total landings ranged between 5 percent (1991 and 1993) and 13 percent (1995). The share of mechanised sector varied between 52 percent (1998) and 90 percent (1996). While the share of pelagic sector fluctuated between 28 percent (1993) and 49 percent (1998 and 1999), that of demersal sector varied between 38 percent (1999) and 62 percent (1993). A perusal of the past records (Alagaraja *et al.*, 1982) from Orissa indicates that the percentage contribution of prawns has improved (from 4 to10 percent) and mechanized sector has tremendously increased (from 3 to 60 percent). Pelagic sector seems to have stabilized at around the 1976 level of 36 percent.

In Andhra Pradesh, the share of prawns in the total landings varied from 8 percent (1992) to 13 percent (1999) showing a slight improvement over the years. The share of mechanised sector varied between 37 percent (1992) and 54 percent (1991) showing the predominance of non-mechanized sector in the state. While the share of pelagic groups varied between 53 percent (1990) and 65 percent (1997), the demersal groups contributed between 21 percent (1998 and 1999) and 31 percent (1991). A comparison with previous study (Alagaraja *et al.*, 1982) indicated a widening of the range of contribution of prawns (from 7 to 11 percent) and a marked improvement in the range of contribution of mechanized sector (from 2 to 27 percent) in Andhra Padesh also. The range of contribution from pelagic groups on the other hand has increased from 48-60 percent and stabilized with narrow fluctuations.

The marine fish landings from the three states of the upper East Coast varied greatly over the years. Contributions of different groups/categories to the total landings in different States over the years also varied significantly. However, under the assumptions made earlier (see section on Methods) on the exploited fish stocks, percentage contributions of different categories may not be different over years and the States. The results of ANOVA on percentage values transformed to arc sine values (Table - 4.4) and rank correlation analysis (Table - 4.5) are presented below.

For the total landings, ANOVA showed highly significant difference between states. However, between years there was no significant difference, supporting the assumptions made earlier. Similar result was obtained in the analysis made for the entire country earlier (Alagaraja *et al.*, 1982) In the case of pelagic, demersal and

Table - 4.4. Result of ANOVA on percentage values transformed to arc sine.

Source		Total landings	Prawn landings	Pelagic landings	Demersal landings	Mechanized landings
Year (df: 9)	*SS*	0.000384	0.042227	0.011324	0.011780	0.123127
	MS	0.000043	0.004692*	0.001258	0.001309	0.013681
State (df: 2)	*SS*	0.975607	0.022951	0.317090	0.441152	1.111377
	MS	0.487804**	0.011475**	0.158545**	0.220575**	0.555688**
Error (df: 18)	*SS*	0.068531	0.031073	0.128575	0.102080	0.186875
	MS	0.003807	0.001726	0.007143	0.005671	0.010382

*** Significant at 1%   * Significant at 5 %*

Table - 4.5. Coefficients of rank correlation, correlation and regression obtained from rank correlation analysis.

Category	Coefficient	Andhra Pradesh	Orissa	West Bengal
	r_s	0.8909**	-0.7576*	-0.6061
Total Landings	r	0.8898**	-0.7229**	-0.4219
	b	0.8545**	-0.7333**	-0.4727
	r_s	0.6303	0.6061	0.6545*
Prawn Landings	r	0.6358*	0.5892	0.6294*
	b	0.6182*	0.5091	0.5697*
	r_s	0.7818*	0.7939*	-0.9212**
Pelagic Landings	r	0.7786**	0.8061**	-0.8337**
	b	0.7576**	0.8424**	-0.8727**
	r_s	-0.7212*	-0.7333*	0.8182*
Demersal Landings	r	-0.7662**	-0.7333**	0.8180**
	b	-0.7455**	-0.7333**	0.8061**
	r_s	0.3455	-0.1879	0.2424
Mechanized Landings	r	0.3455	-0.1879	0.2333
	b	0.3455	-0.1879	0.2303

r_s = *rank correlation coefficient*, b = *regression coefficient*, r = *correlation coefficient*,.** Significant at 1%   * Significant at 5%

mechanized sectors also ANOVA indicated highly significant differences between the States but no significant differences over the years (Table - 4.4). For the prawn landings, however, there was highly significant difference ($p<0.01$) over the States and significant difference ($p<0.05$) over the years. This indicated that the production of prawns is responsive to spatial and temporal changes in the fishing pressure in this region. In contrast to the present results, earlier analysis (Alagaraja *et al.*, 1982) for the entire country showed no significant differences for prawns between years whereas significant difference was observes for mechanized sector between years. It should be noted that the data used in the previous study pertain to a period when mechanization was still in the developing stage.

In order to see whether there is any trend in the contributions over the years within each State, rank correlation coefficients (r_s) were calculated along with correlation coefficient (r) and regression coefficients (b) for the three states (Table - 4.5). In the case of total landings, a significant positive relationship was observed in the State of Andhra Pradesh while it was significantly negative in the case of Orissa and negative but not significant in the case of West Bengal. The prawn landings, on the other hand, showed significant positive relation in Andhra Pradesh and West Bengal. Pelagic landings exhibited highly significant positive relation in all the three states. The technological changes in the traditional sector in Andhra Pradesh and West Bengal, which mostly account for the pelagic species, could be responsible for this positive trend. While demersal landings indicated highly significant negative relationship in Andhra Pradesh and Orissa, it was highly positive in West Bengal. The negative relations could be indication of response of over-exploited demersal stocks off Andhra Pradesh and Orissa coasts and optimally exploited stocks off West Bengal. The coefficients for mechanized landings were positive in Andhra Pradesh and West Bengal and negative in Orissa but all were not significant. This could be taken as an indication of saturation of fishing pressure by mechanized vessels.

4.5. Exploitable potential

The potential estimates of resources of the northeast coast of the Indian EEZ revalidated by the Working Groups (WG-I and WG-II) of experts do not give the state-wise break-up (Anon., 1991 and Anon., 2000). Further, the absolute figures of potential in different depth zones and regions conceal some important information. The density of resource distribution and qualitative aspects are not available for informed decision making.

When the demersal fishery potential per unit area (km^2) in different zones is examined, an interesting picture emerges (Table – 4.6). The average yield is highest along the upper East Coast followed by Northwest Coast, Southwest Coast and Southeast Coast in that order. The gradient in resource potential is disturbed at 100-200 m depth zone in all the three regions excepting the upper East Coast. Along the Northwest coast, surprisingly, the average yield at 100-200 m depth zone is higher than that at 0-50 m depth zone. The fact that the upper East Coast is richest in the 0-50 m depth zone as well as 50-100 m zone has great significance to the trawl fishery. However, Vijayakumaran (1998[a,b]) mentioned that with the present technology, operations will be viable up to 70 m and will not at all be viable beyond 100-m.

The potential estimates given for the upper East Coast under recent revalidation seems to be quite unrealistic. Thus the potential resources within 200-m depth of the upper East Coast given by the earlier report (Anon., 1991) could be summarized in Table - 4.7. Assuming the present trend of technology and market conditions would continue in the short-run, the potential within 70 m depth could be termed as exploitable for the present analysis. Thus the maximum exploitable potential of the upper East Coast would be around 460000 t. Even assuming that appropriate

Table - 4.6. The region-wise, depth-wise estimated yield (tonnes per square km) of demersal resources in the Indian EEZ.

REGION	DEPTH ZONE (m)				AVERAGE
	0 – 50	50 – 100	100 – 200	200 – 300/500	
Northwest Coast	5.4	2.81	6.32	0.07	**3.18**
Southwest Coast	6.88	2.09	2.85	1.98	**2.22**
Lower East Coast	6.07	1.14	2.21	0.61	**1.45**
Upper East Coast	7.23	4.21	3.07	0.29	**3.42**
AVERAGE	**6.2**	**2.7**	**3.89**	**1.17**	**2.24**

Source: Vijayakumaran, (1998 [a, b])

Table - 4.7. The summary of depth-wise estimated potential (thousand tonnes) of demersal and pelagic resources of the upper East Coast of Indian EEZ.

DEPTH ZONE (m)	0-50	50 – 100	100 -200	TOTAL
Demersal (UEC)	309.7	72.9	44.5	**427.1**
Pelagic (UEC)	114	25	21	**160**
TOTAL	**423.7**	**97.9**	**65.5**	**587.1**
Cumulative Total	**423.7**	**521.6**	**587.1**	

Source: Adapted from Anon., (1991)

technology and markets would develop in the long run, it would be reasonable to consider only the resources within 100 m as exploitable. Thus an estimated 521600 t of fish can be harvested form the upper East Coast and this estimate could be assumed as the limit under the most ideal conditions of technology and markets.

The exploitable potentials of the three maritime states were worked out by different methods using available data (Table - 4.8). The maximum contribution approach using 10-year data yielded an estimate of 479471 tonnes, more or less similar to the limit mentioned above. The relative response approach using 25 years data yielded an estimate of 387071 t, which is 18 percent less than the above-assumed limit. The average of the ten years worked out to be 288054 t, which is 38 percent less than the limit assumed. The maximum total landing during 1975-99 periods was 347140 t, which is about 26 percent less than the limit assumed. The working group method gave an expected yield of 302696 t, which is much closer to the current average yield.

4.6. Conclusions

The annual marine fish landings in the three States of the upper East Coast during 1990-1999 have shown increasing trends with varying degrees of fluctuation. The influence of fishery independent and fishery dependent factors is evident. Percentage analysis indicated moderate increasing trend in the contribution of prawns during this period. The expanded fishing effort and changing strategies of fishing vessels may be responsible for this increase. The ANOVA showed significant difference in the total landings between States but not between years indicating a variation in spatial abundance (but not temporal) of the resources and application of fishing effort. A significant difference in prawn abundance in space and time is in response to the varying pattern of fishing effort. Rank correlation analysis indicated significant positive relation in pelagic landings in all the three

Table - 4.8. Estimates of exploitable potential (tonnes) by different methods based on landing data for different years.

Method	West Bengal	Orissa	Andhra Pradesh	Total
Maximum Contribution (1990-99)	124643	102351	312900	479471
Relative Response (1975-99)	48771	47170	210193	387071
Maximum Landings (1975-99)	91969	64736	233255	347140
Working Group Method (1990-99)	76796	53833	172067	302696
Average Production (1990-99)	71637	51182	165234	288054

States, obviously due to the expansion of fleet and technological change in the traditional sector. An overexploited state of the demersal stocks off Orissa and Andhra Pradesh and saturation of fishing pressure is also indicated.

The estimates of potentials have been made based on the biological capacity of the stocks, under various assumptions. The choice of any of the three estimates must be made with caution since the techno-economics of harvesting plays a crucial role in deciding the viability of exploitation. It is reasonable to presume that under the present level of technology, with slight improvement in infrastructure and modification of strategies, the potential estimated by relative response model is quite achievable. The estimate based on WG method could be taken as a lower (pessimistic) limit and that by MCA could be taken as an upper (optimistic) limit. However, the state-wise break-up obtained by the different methods need not be considered as a criterion for resources sharing. The present pattern of distribution of effort and other socio-economic factors need to be taken into account for deciding the sharing formula.

CHAPTER – V

TECHNOLOGY OF FISHING

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TECHNOLOGY OF FISHING

5.1. Introduction

Fishing is one of the age-old occupations of a dominant section of people settled in coastal areas. Fishing methods have probably been evolved over centuries and are very effective in catching different varieties of fish. The temporal and spatial variations in endowments and needs have influenced this process of evolution.

A number of gadgets and implements have been developed, tried and modified over years all over the world for capture of different types of aquatic organisms (von Brandt, 1972). Hornell (1924 and 1938) was the earliest to provide a detailed description of fishing gear and tackles used in India. Bal and Banerji (1951) provided an account of the fishing craft and tackles of the Indian seas. A comprehensive inventory of the craft and gear of marine fishery sector was taken through an All India Marine Fisheries Census conducted by CMFRI in 1980 (CMFRI, 1981). In recent years some workers have paid attention to provide accounts of the craft and gear used in the marine fisheries (Chennubhotla *et al.*, 1999) and gill nets (Ramarao *et al.*, 2002) of Andhra Pradesh. The application of modern technology in fishing resulted in different commercial fishing methods, which use machine power for running the boat as well as operating the gears (Sainsbury, 1971). Hameed and Boopendranath (2000) provided details of the latest developments in fishing methods and fishing gear technology, with reference to the marine fisheries in India. Verghese (1994) and Vijayakumaran (1999[a]) have discussed the different aspects of fishing operations of industrial trawlers along the upper East Coast.

The diversity of fishing gears is far greater than that of fishing craft. The simple forms of gears like hooks and line and traps made out of indigenous material are operated from traditional fishing crafts. On the other hand, very large trawl nets, purse seines and long lines made of synthetic material are operated from sophisticated vessels equipped with the state of art electronic equipment for fish finding and navigation. The fishermen and R&D agencies are constantly improving these gadgets to make them more efficient in capture of fish as well as expenditure of energy.

Before elaborating on the economics of different types of fishing operations, it is important to understand the characteristic features of technology of fishing in a systematic way. In this Chapter the salient features of fishing craft and gears of the traditional and industrial sector of the marine fisheries along the upper East Coast of India will be examined. This Chapter will also dwell up on different craft-gear combinations of the traditional sector and the temporal and spatial change in fishing technology and fishing intensity. An attempt will be made to analyze the capacity utilization of major gears as well as to delineate the capabilities and limitations of different types of vessels.

5.2. Model of Capacity Utilization

Estimation of capacity utilization of different gears has been was made based on Peak-to-peak method (Greboval, 1999). This method is suitable in cases where basic catch and aggregate fleet data are available (Pascoe *et al.*, 2004). Here changes in peak catch rates are assumed to be due to technological change. The average rate of technical change is applied to derive a full capacity rate. The Technology Trend (TT) is calculated using the formula:

$$TT = \frac{CR_2 - CR_1}{t_2 - t_1} \qquad 1$$

Where CR_2 and CR_1 are the catch rates of second and first peaks and t_2 and t_1 are the corresponding years. Capacity utilization was derived from the observed rate as a percentage of the expected rate as per the technology trend. The gear wise catch and effort data, pooled for the upper East Coast, for the period 1990-1999 from NMLRDC of CMFRI have been used for this purpose. Further, variable input utilization (VIU) has been calculated using the following formula (FAO, 1998; Pascoe *et al.*, 2004):

$$VIU = \frac{DaysAtSea(Observed)}{DaysAtSea(Potential)} \qquad 2$$

For this purpose bag netters were assumed to have a potential to operate for 150 days whereas other mechanized crafts and traditional crafts were assumed to have a potential for operating 200 days at sea. The analysis of capabilities and limitations of different crafts have been made based on the information collected during survey with the support of published information.

5.3. Features of Fishing Gears

The salient features of gears and tackles used for fishing can be better understood following a broad classification given by von Brandt (1972). This classification based on the catching method or operation of gears is briefly summarized below with relevant examples applicable to the upper East Coast of India.

a. *Fishing without gear:* Grasping by hand, by diving is practiced in the collection of clams, oysters, mussels and other molluscs from estuaries, bays and coastal waters.

b. *Grappling and wounding gear*: Clamps, tongs, raking devices, spears, lances harpoons etc. are very popular in inland water bodies, lagoons and northern latitudes (whale harpoons and spears of Eskimos) and are very rare along the upper East Coast.

c. *Stupefying devices*: The use of chemicals and ichthyotoxic plant extracts, explosives and deoxygenating methods to kill or stupefy fish are sometimes reported in certain parts of the coast.

d. *Lines*: This method involves use of hooks set on lines and is a very common fishing method employed by traditional non-motorised and motorised vessels of the upper East Coast. In addition, a few large mechanized vessels are engaged in long lining for tuna and larger fishes.

e. *Traps:* This is a very old traditional method suitable for capturing sparsely distributed animals dwelling at or near bottom, some versions of which are currently used for catching perches, lobsters and crabs.

f. *Bag nets*: These bag shaped nets are kept open vertically by a frame at the mouth end and take advantage of the tidal currents for capturing fish. Bag nets are one of the dominant gears along the West Bengal and north Orissa coast.

g. *Dragged gear*: This group includes all net bags or net walls, which are towed through the water at or near the bottom or column. In this category, the bottom trawl or shrimp trawl is the most dominant gear operated in Indian waters and forms the main component of the industrial fishery along the upper east coast. Mid-water (column) trawling is not yet a popular method of fishing along this coast.

h. *Seine nets*: This group consists of nets with very long wings, body (with or without bag) and towing warps. The mode of capturing is by surrounding a certain area and towing the gear over this area with both ends to a fixed point on the shore or a vessel. Along the upper East Coast, the most important traditional gears namely boat seines and shores seines belong to this category.

i. *Surrounding nets*: This category of nets surrounds the fish schools from all the sides and closes the net from below retaining the fish in the purse of the net. The most common nets of this class namely purse seine and ring seine are very popular along the West Coast but ring seines have been recently introduced along the upper East Coast.

j. *Lift nets*: In this method, a flat or bag like net kept dipped down in water column for some time is lifted to catch the fish in the column above the net. The most popular *Chinese dip net* of Kerala is a typical example. Smaller hand held versions of this net and larger nets operated by four vessels are more common along the upper East Coast.

k. *Falling gear*: The nets in this category capture fish by covering from above, the edges of the net touching bottom first before the fish can escape. The omnipresent cast net belongs to this category.

l. *Gill nets*: These are single walled nets in which the fish get gilled in the mesh. This passive gear is operated as either set at different depths or allowed to drift. This is the most important gear operated by traditional sector and second important gear used by mechanized vessels along the upper East Coast.

m. *Tangle nets*: These nets are single, double or triple walled nets, which capture fishes by entangling. The most important gear under this category is the three walled (trammel) *disco nets* operated by the traditional sector along the upper East Coast.

5.4. Fishing Crafts

5.4.1. Traditional Sector

The traditional crafts such as *catamarans (Teppa)*, *navas*, *masula boats,* fiberglass boats and *dhingies* operated along the upper East Coast are the most numerous. They deploy a variety of gears and tackles depending on the target species being exploited. For exploitation of the demersal fishes they operate bottom set gill nets, trammel nets (*disco nets*) and bag nets. Shore seines and boat seines catch both pelagic and demersal resources. For exploiting the columnar (mainly pelagic) resources they use gill nets and hooks and lines. Based on the type of construction and the source of power for propulsion, traditional crafts could be distinguished as a) n*on-motorised b) inboard motorised* and c) o*utboard motorised.* A brief description of the various types of fishing craft, their characteristic features and capabilities is provided below.

5.4.1.1. Non-motorised Traditional Crafts

a. *Catamaran (Teppa)*: These are the simplest of all the crafts and may comprise of three to five logs tied together firmly with hemp rope near the fore and aft ends. Often these wooden logs are shaped appropriately to form two halves, which when joined together form a shallow canoe-like craft. While larger of these types are dismantled and brought as halves to the beach, smaller ones are kept attached throughout. The overall length of this class of crafts varies between 4.2 m to 7.6 m with breadth varying between 0.6 m and 1.0 m. Propulsion is by oars and sails. When conditions are favourable these crafts can venture far into the sea. Catamarans have evolved as the most suited beach landing crafts for the East Coast where severe wave action and currents prevail.

b. *Large Plank-built Boats (Nava/Kakinada Nava)*: These are larger and wide boats built of planks and strengthened with an inner frame of wooden ribs. An average boat of this class may have about 9.5 m LOA, a beam of 2.10 m and a draft of 0.85 m. Propelled by oars and sail, these boats can venture into comparatively deeper waters during favourable sea conditions.

c. *Plank-built Boats (Padava/ Kuttupadava or Masula Boats):* Unlike the navas, these boats are built with light wooden planks stitched together and without any ribs. These boats are much varied in size ranging from 4 to 12 m and are operated in the inshore waters. The larger ones are entirely used for shore seine operations whereas the medium and smaller ones are used for gill net operations.

d. *Dhoni (Shoedhoni)*: This shoe shaped craft is wide and flat forward, with a small keel fitted to the front, and has a short stern and a bow section strongly flared. Made of teakwood planks, these crafts measure 7.6 m LOA. These paddle-propelled boats are endemic to estuarine and bay area of Kakinada and are used for operation of stake nets.

5.4.1.2. Motorised Traditional Crafts

a. *Motorised Plank-built Boat*: These are large wooden plank-built (generally teakwood) boats fitted with a 10 HP inboard engine. There is no rudder and the change of direction is effected with a long oar. A mast and sail are attached to serve in emergency or to take advantage of the favourable winds. These crafts are used for operation of synthetic drift gill nets. Along the Orissa-West Bengal coast, plank built boats fitted with 10-20 HP inboard engine and rudder control, operating gill nets are very common.

b. *Motorised fibreglass-boat (Mara Padava)*: These boats are built out of wood and marine plywood and coated with synthetic fibreglass material all over. Fitted with 10 HP inboard diesel engines, these flat-bottomed boats have an average LOA of 8.45 m, 2.27 m beam, 0.83 m depth, a 0.45 m draught and have a gross tonnage of 2.5 t. These boats have rudder and a control bar for changing direction and additional stability is ensured by a leeboard fixed in the midline of the boat and/or an outrigger fixed to the side. There is provision for fixing a mast and sail in emergency and the boat is generally used for synthetic drift gill net fishing.

c. *Motorised Fibreglass Catamaran (Mara Teppa)*: These are all weather catamarans made out of plywood, wood and fibregalss and fitted with 6.5-10 HP outboard engines. These crafts have an average LOA of 8.5 m and a width of 1.85 m. The aft, generally wide by 0.8 m, is provided with a pivoting metal base for fixing the motor. The slightly long shaft and propeller can be moved vertically in and out of water as well as horizontally to change the direction. These vessels venture in to deeper areas, operating different types of synthetic drift gill nets.

5.4.2. Mechanised Sector

The mechanized sector, which employs different types of machine-powered boats, is quite important in terms of total investment as well as quantity and value of the catch landed. A brief description of the various types of fishing crafts their characteristic features, capabilities and operations is provided below.

a. *Gill-netter:* The mechanised gill-netters are wooden *Pablo* type boats measuring about 9 m LOA. They are fitted with an inboard engine and are the forerunner of the indigenous mechanized trawlers of the East Coast. The operation of these boats became comparatively uneconomic since early nineteen eighties and have subsequently been giving way to larger vessels capable of undertaking stay fishing and handling large sized nets (Plate-8 and Plate-11).

b. *Small and Medium Mechanised boats (Royya, Sorrah* and *Sona boats):* These are wooden boats operating shrimp trawls in the inshore waters. The *Royya* type measures 9.6 m LOA and has 2.9 m breadth, 1.07 m draught and is fitted with 63 - 68 HP engines. The *Sorrah* type measures 11.2 m LOA and has 3.2 m breadth, 1.25 m draught and is fitted with 68-93 HP engines. The *Sona* boat has 13.1 m LOA, 4.1 m breadth, 2.8 m draught and is fitted with 100-120 HP engines. These vessels are fitted with trawl winch and carry icebox for keeping the catch fresh. *Royya* and *Sorrah* boats are capable of staying at sea for 3 –5 days whereas *Sona* boats have an endurance of 8-

10 days. These boats operate trawl nets in the coastal seas in the depth range of 10-50 m.

c. *Mini trawlers*: This class of vessels are made of wood and the most common ones have 16 m LOA, 5.08 m breadth, 2.15 m draught, and 145 HP engines. They carry ice and have an endurance of 10-15 days. They deploy two identical shrimp trawl nets at a time using outriggers and operate in the area from off Pentakota to off Sundarbans, usually within the depth range of 20 to 70 m (Plate-7).

d. *Large Trawlers*: These are steel vessels the smaller of which have 23.19 m LOA, 7.3 m breadth and 3.08 m draught and are fitted with 380 HP engine. The larger ones, namely ASI vessels, under this class have 24.95 m LOA, 7.44 m breadth and 2.8 m draught and are fitted with 500 HP engine. While the former has an endurance of about 18 to 28 days, the latter can stay up to 45 days and both types have onboard freezing and cold store facility. They operate within 20-70 m depth along the coast from off Pentakota to off Sundarbans and deploy four trawl nets at a time using outrigger (Plate-7).

The technical specifications and capabilities of different mechanized trawlers are summarized in Table - 5.1.

5.5. Craft-Gear Combinations

Mechanised fishing operations demand gear-specific deck arrangements onboard the vessels. Though mechanized fishing vessels designed for two different methods are available, they are not operational along the UEC. In some parts of Orissa, some trawlers, after removing the winch, are used for gill-net fishing and are refitted with winch for trawling during alternate seasons. An interesting feature of the traditional

Table – 5.1. Technical specifications and capabilities of different types of trawlers operating along the upper East Coast

SPECIFICATIONS	LARGE TRAWLERS	MINI TRAWLERS	*SONA* TRAWLERS	SMALL TRAWLERS
LOA range (m)	21 – 28	16-18	13-15	9-12
Mean breadth (m)	7.3	5.1	4.1	2.8
Mean draught (m)	3.08	2.2	1.8	1.1
G T (t)	156 – 180	40-50	18-30	10-17
N T (t)	35 – 79	12.8	5.5	-
Engine (Make)	Caterpillar, MAN, Yanmar	Ruston, MWM, Ashok Leyland	Ashok Leyland	Ashok Leyland
Horsepower	350 – 624	145 – 180	100-120	60-90
Crew Strength	12 to 15	10-12	7-10	5-8
Chill Tank Capacity	3.5	NA	NA	NA
Fish Hold Volume (m^3)	60 –110	7.5 –15	NA	NA
Fish Hold Temperature °C	-18	-18	NA	NA
Type of Hull	Steel	Wood / Steel	Wood	Wood
Endurance (days)	20 – 30	10 – 15	8 – 10	3-5
Fuel Capacity (kl)	45 – 80	9 –12	5-6	1-2
Fresh Water Capacity (kl)	10-20	6	2	1-2
Freezing /Ice capacity	Plate Freezer, IQF 2 tpd	Ice (10 t)	Ice (5 t)	Ice (2 t)

crafts is the inherent flexibility with respect to the choice of gears to be deployed. A perusal of the combination of traditional craft and gears operated along the upper East Coast will enlighten this point (Table - 5.2). Generally, the fishermen decide the type of gear to be operated based on the prevailing sea conditions, which would change in time and space. Similarly currents and wind determine the seasonal operation of certain gears such as shore-seine and daily operation of boat-seine. The ingenuity and traditional knowledge of the fishermen in understanding the natural phenomena and planning the day-to-day fishing operation are remarkable.

5.6. Changes in Fishing Technology

Marine Fish production in India has increased from 1.45 million t in 1981-82 to about 2.97 million t in 1997-98, showing an average growth rate of about 8 percent per annum during this period. This growth in production was achieved by both spatial expansion of fishing areas, drastic changes in the fishing techniques and intensification of fishing effort by increased number of different types of fishing craft and gears.

From 1980 to 1998 there has been a marked increase in all categories of mechanized fishing vessels all along the Indian coast, though a marginal decrease was observed in the number of traditional craft. Except the seine nets, traps and scoop nets, all other fishing gears significantly increased in number during this period (Table - 5.3). Overall there was a change towards intensification of mechanized fishing methods. This trend is visible even in traditional sector as nearly 40 percent of the traditional fishing crafts were motorised during this period.

5.6.1. Changes along the UEC

The number of fishing craft increased significantly from 1980 to 1998 along the UEC also. While the traditional crafts were more along the East Coast, motorized

Table-5.2. The important combinations of traditional craft and gear used in the exploitation of the coastal marine fishery resources along the upper East Coast.

	Type of Craft	Important Gears Used	Status	Season
1.	Plank-built boat (Small)	i) Drift gillnets	M	Round the year
		ii) Bottom set gill nets	M	Round the year
2.	Plank-built boat (Big)	i) Shore seine	M	November- April
		ii) Gill net	S	Round the year
	Plank-built boat (*Nava*)	i) Drift gill nets	M	Round the year
		ii) Bottom set gill nets	M	Round the year
3.	Inboard motorized boat	i) Synthetic drift gill net	M	Round the year
		ii) Hooks and line	S	Round the year
		Iii) Long line	S	November- April
4.	OB motorized boat	i) Synthetic drift gill net	M	Round the year
		ii) Hooks and line	S	Round the year
		Iii) Long line	M	November- April
5.	Fibreglass *Teppa* (OBM)	i) Drift gill net	M	Round the year
		ii) Hooks & line	S	Round the year
6.	Fibreglass *Teppa* (NM)	i) Boat seines	M	Round the year
		ii) Drift gill net	M	Round the year
		Iii) Disco net	M	Round the year
		iv) Hooks & line	S	Round the year
7.	Catamaran (*Teppa*)	i) Boat seines	M	February- May
		ii) Drift gill net	M	Round the year
		Iii) Disco net	M	Round the year
		iv) Bottom set gill nets	M	Round the year
		v) Hooks & line	S	Round the year
8.	*Nava*	i) Gill nets	M	Round the year
		ii) *Ila vala* (encircling net)	M	Round the year
		iv) Hooks & line	S	Round the year

M: Main, S: Secondary

Table-5.3. Change in number of different types of fishing craft and gears along the Indian coast from 1980 to 1998.

	Particulars	1980	1998	Change (%)
1.	**Fishing Crafts**			
	a) Mechanized			
	Trawlers	6288	30979	393
	Gill-netter	2362	9968	322
	Doll netter	241	5538	2198
	Purse seiners	221	1006	355
	Others	177	1579	792
	Total	**9289**	**49070**	428
	b) Traditional			
	Plank-built boats	37904	39951 (43)*	5
	Dug-out canoes	21684	17297 (38)*	-20
	Catamarans	73431	58921 (29)*	-20
	Others	1722	11349 (89)*	559
	Total	**134741**	**127518 (40)***	-5
2.	**Fishing gears**			
	Trawl nets	14165	151466	969
	Purse-seines	238	1216	411
	Drift/ set gill nets	216037	1534555	610
	Boat-seines	29976	8166	-73
	Fixed bag nets	48817	77582	59
	Hooks and lines	56676	89261	57
	Rampans	187	257	37
	Shore seines	18841	4481	-76
	Traps	98825	4068	-96
	Scoop nets	6080	3719	-39
	Others	95804	86527	-10
	Total	**585646**	**1961298**	235

* Motorised vessels (Percentage in parenthesis) included; Source CMFRI.

and mechanized vessels are more along the West Coast. However, the overall percentage increase in mechanized vessels (mainly trawlers and gill-netters) was significantly higher along the UEC than the country as a whole (Table - 5.4). On the other hand, the percentage decrease in the number of traditional craft is also higher (note the complete vanishing of dug out canoes) along the UEC compared to the national figures. Motorised crafts among the traditional units along the upper East Coast was only 30 percent compared to the national figure of 40 percent.

The number of fishing gears also increased along the upper East Coast significantly from 1980 to 1989. While the percentage increase in trawl nets was much higher along UEC compared to the national figures, increase/decrease of other gears was less than that of the national figures (Table - 5.5). Obviously there is a lower rate of displacement of traditional methods and delayed adoption of new methods along the UEC. For example, the adoption of ring seines along the UEC has occurred when the net was subjected to regulation along the West Coast.

5.6.2. Fishing Intensity

Consequent to the increase in number of fishing craft and gear, the intensity of fishing also increased all over the country. Examining the current strength of the fleet per unit length of coastline in different maritime States will give a better idea of the magnitude of fishing (Table - 5.6). It could be seen that on an all India basis, there are more than six mechanized vessels, nearly sixteen traditional vessels and about 183 gill nets for every kilometre of the coastline. The number mechanized boat per km along the West Bengal coast is much higher than that of the other two States of the UEC. Andhra Pradesh tops in density of traditional craft and gill nets along the UEC.

Table-5.4. Change in number of different types of fishing crafts along the three maritime States of the UEC from 1980 to 1998.

Fishing Crafts	WB		OR		A P		Total (UEC)		Change
	1980	1998	1980	1998	1980	1998	1980	1998	%
Mechanised									
Trawlers	-	590	-	1203	447	1779	447	3572	*699*
Gill-netters	247	3197	106	791	9	237	362	4225	*1067*
Dolnetters	-	-	-	6	-	105	-	111	*NA*
Others	63	402	-		-	-	63	402	*538*
Total	**310**	**4189**	**106**	**2000**	**456**	**2121**	**872**	**8310**	***853***
Traditional									
Plank built	3972	3726	3262	2859	11359	8948	18593	15533(26)	*-16*
Dug out canoes	89	-	186	-	1781	-	2056	-	*-100*
Catamarans	-	-	6276	4777	22198	17408	28474	22185(26)	*-22*
Others	-	112	4	236	675	1979	679	2327(92)	*243*
Total	**4061**	**3838**	**9728**	**7872**	**36013**	**28335**	**49802**	**40045(30)**	***-20***

Figures in brackets against 1998 traditional crafts of UEC are the percentage of motorised crafts;
Source CMFRI

Table-5.5. Change in number of different types of fishing gears along the three maritime States of UEC from 1980 to 1998.

Fishing Gears	WB		OR		A P		UEC		Change
	1980	**1998**	**1980**	**1998**	**1980**	**1998**	**1980**	**1998**	**%**
Trawl nets	-	2297	-	1806	823	7998	823	12101	*1370*
Purse seines	-	28	-	3	-	-	-	31	*NA*
Gill nets	2467	7519	10427	23198	42385	66778	55279	97495	*76*
Boat seines	-	159	2676	666	9738	3489	12414	4314	*-65*
Fixed bag nets	6200	10443	2778	270	14617	1058	23595	11771	*-50*
Hooks & lines	869	624	15265	1243	10752	35070	26886	36937	*37*
Ring seines	-	23	-	-	-	58	-	81	*NA*
Shore seines	436	297	2893	207	3042	949	6371	1453	*-77*
Traps	61	189	515	-	130	158	706	347	*-51*
Scoop nets	345	448	37		2925	1943	3307	2391	*-28*
Others	2433	4580	5201	6915	37199	16396	44833	27891	*-38*
Total	**12811**	**26607**	**39792**	**34308**	**121611**	**133897**	**174214**	**194812**	***12***

Source CMFRI

Table- 5.6. Number of mechanized boats traditional craft and gill nets per km length of coastline in different maritime states as per 1998 rapid survey.

States	Mechanized boats	Traditional crafts	Gillnets
West Bengal	26.68	24.45	47.89
Orissa	4.17	16.4	42.77
Andhra Pradesh	2.18	29.09	63.61
Tamil Nadu	7.37	37.29	145.06
Pondicherry	10.27	60.76	214.07
Kerala	8.62	43.02	72.11
Karnataka	10.81	26.93	38.94
Goa	9.39	12.86	19.98
Maharashtra	18.66	8.96	231.23
Gujarat	6.36	3.88	628.9
All India	**6.1**	**15.86**	**183.28**

Source: Vijayakumaran (2004)

These figures are only indicative of the fishing pressure and must be viewed cautiously since the spatial distribution of fishing effort is not uniform, especially in the case of mechanized fishing vessels. There is also a great degree of overlap of operational boundaries of both mechanized as well as traditional vessels from adjacent states.

5.7. Capacity Utilization

The peak-to-peak analysis using the catch and effort data for 1990-99 revealed certain interesting features with regard to the trend of observed and expected CPUE in different years. In general, the gears performed above expectation during the early years and their performance declined during the later years of the decade. The trawl gear was most efficient in the lot as its observed catch rates did not vary much from the expected catch rate and fluctuations are not great (Fig.5.1a). On the average, trawl gears recorded above 100 percent utilization of capacity and 99 percent VIU (Table - 5.7).

Mechanised gill nets exhibited somewhat wide fluctuations in the catch rate and performed below the expected rate for most of the period (Fig. 5.1b) and overall, the capacity utilization was 69 percent and VIU 89 percent (Table - 5.7). The observed rate of mechanized bag nets more or less followed the expected rate till 1993, plummeted down thereafter and remained stable at the lower level for the remaining years (Fig. 5.1c). The decadal average capacity utilization for MBN was only 54 percent and VIU 100 percent (Table - 5.7).

The OBM gill nets also showed wide fluctuation in the early years and a decline and stabilization during later years (Fig. 5.2a). Due to the influence of extremely high catch rates in 1990 and 1992, the average capacity utilization worked out to be 142 percent for OBM gill nets while VIU was 90 percent (Table-5.7.). The observed

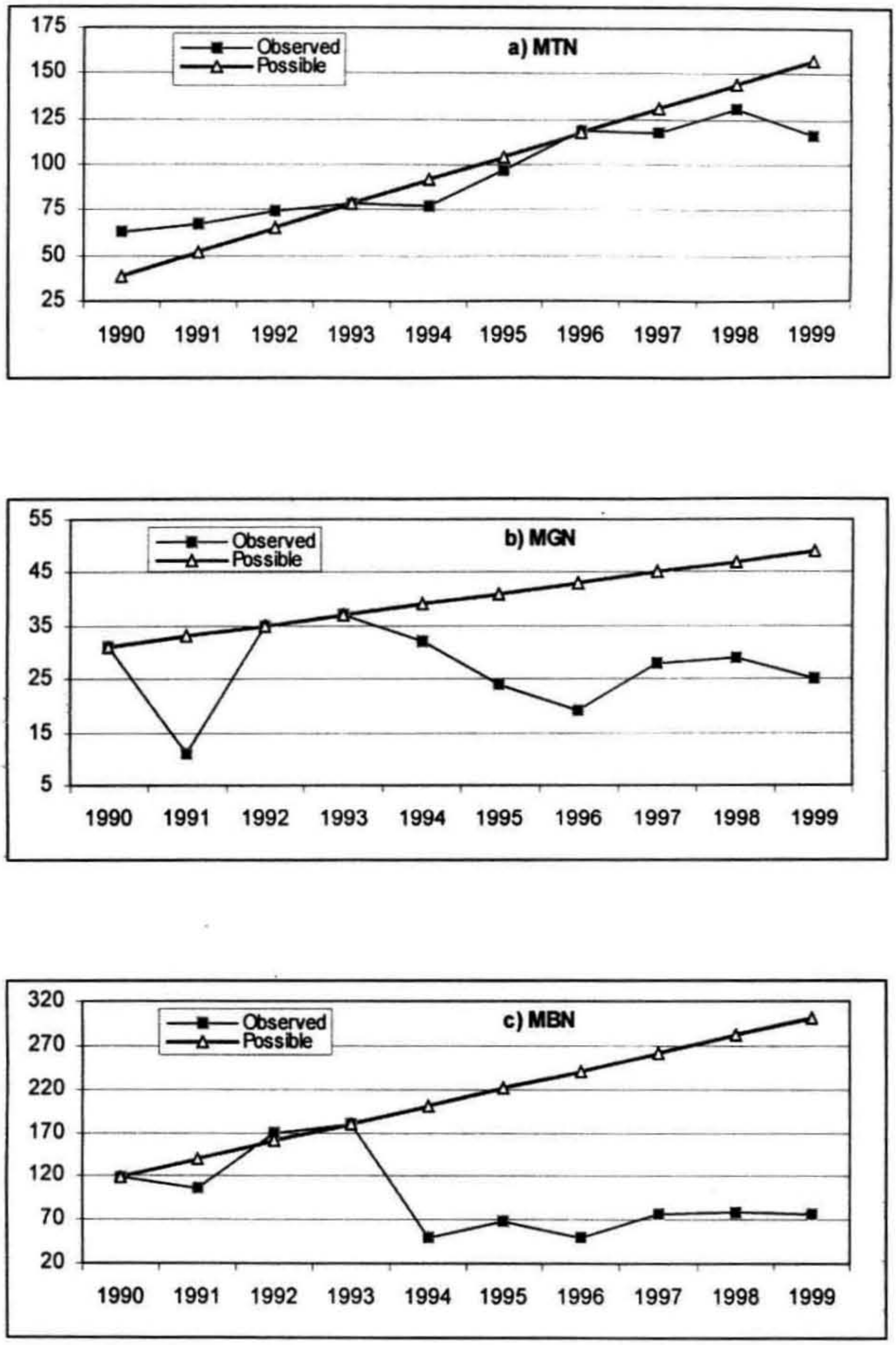


Figure.5.1.The capacity utilization as represented by expected and observed catch rate (t unit^{-1} year^{-1}) of a) Mechanized trawl nets, b) Mechanized gill nets and c) Mechanized Bag nets along the UEC during 1990-1999

Table-5.7. Capacity utilization and VIU (percentage) of different gears along the upper East Coast of India during 1990-1999.

	Capacity Utilization (%)					
	MTN	**MGN**	**MBN**	**OBGN**	**OBOTH**	**NM**
1990	165	100	100	760	-	88
1991	130	33	77	56	17	100
1992	114	100	107	231	59	83
1993	100	100	100	100	100	76
1994	84	82	25	100	67	39
1995	93	59	31	52	27	59
1996	100	44	21	31	100	76
1997	89	62	29	27	29	71
1998	91	62	28	24	8	98
1999	74	51	25	34	15	87
Average	**104**	**69**	**54**	**142**	**47**	**78**
	Variable input utilization VIU (%)					
1990-99	**99**	**89**	**100**	**90**	**90**	**97**

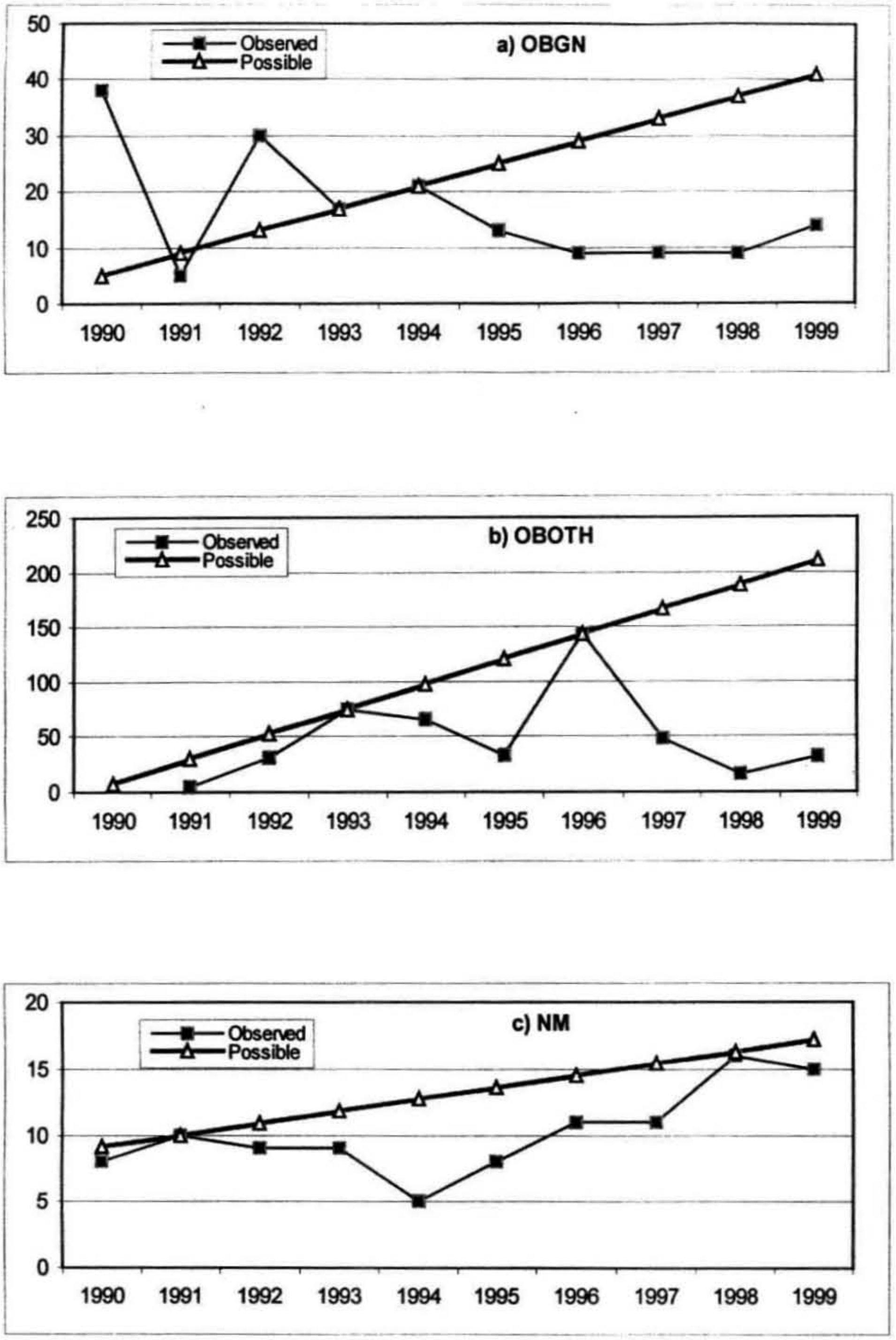


Figure.5.2.The capacity utilization as represented by expected and observed catch rate (t unit^{-1} year^{-1}) of a) OB motored gill nets, b) Other OB motored gears and c) Non-mechanized gears along the UEC during 1990-1999.

catch rates of other outboard-motored gears also showed wide fluctuation mostly below the expected rate (Fig. 5.2b) and the decadal capacity utilization worked out to be 47 percent and the VIU was 90 percent (Table-5.7.). The catch rates of non-mechanised gears were below the expected rate for most of the period (Fig. 5.2.c). The average capacity utilization for the decade worked out to be 78 percent and VIU 97 percent for NM units (Table - 5.7). The VIU showed that both mechanized trawlers and traditional gears are by and large utilized near optimum and bag nets are operational during five months and are fully utilized.

5.8. Capabilities and Limitations

The capacity of different classes of vessels in exploiting the coastal resources of the UEC depends on various factors. In addition to the constraints imposed by the spatial distribution of resources as well as price structure of different species, the physical capacities has been observed to pose major constraints on the operation of vessels. A preliminary analysis of the influence of these constraints on the extent of operation and endurance is appropriate. For all the classes of vessels the decision rules are governed by the limiting factors such as:

- Availability of fish and other conditions for the type of gear being operated,
- The maximum distance from which the vessels can safely return home under the prevailing sea conditions,
- The minimum depth and the maximum depth within which the vessel can function safely and optimally,
- The maximum cruise time allowable to maintain the catch in good condition,
- Time duration for which the available supply of fuel, food and water would last,
- The time duration needed for filling the fish hold or catching enough to ensure a minimum level of return.

These aspects can be elaborated discussing separately the capabilities and limitations of traditional and mechanized vessels.

5.8.1. Traditional Crafts

Traditional non-motorized crafts can operate from relatively shallow waters to deeper waters depending on the availability of fish and type of gear deployed. Generally they seldom venture to go beyond 16 km from the shore because of the limitations with regard to their gears as well as the time needed to return back to shore. Motorized traditional crafts often venture beyond 16 km depending on the availability of good catch and the gear being used by them. Under normal conditions, for the traditional non-motorized vessels the decision rules governed by the limiting factors converges to a single day operation within 16 km. For motorized traditional crafts, the range of operation may extent up to a distance of up to 40 km. While the optimum depth of operation is within 20 fathom (f), the depth of operation may extent up to 50 f for hooks and line, and 30 f for all other gears.

5.8.2. Mechanized Vessels

Mechanized fishing vessels tend to operate within a stipulated range of depth not far from the port. However, increase in number of different types of mechanized fishing units, especially trawlers, forced them to expand fishing beyond the conventional areas. Currently most of the mechanized trawlers are undertaking stay fishing at distant grounds. The major reasons for this development are the increase in number of units and intensification of fishing, overexploitation and depletion of fish stocks in the nearby grounds and increasing price of fuel, which accounts for up to 70 percent of the operational cost. The stay fishing has helped them to save fuel on frequent trips to the ground and back to the port.

While there are various factors, which decide the optimum operational conditions, most of the vessels are forced to opt for certain pattern of operation due to some inherent limiting factors.

The safe depth and the operational capability such as wire rope length decide the depth range of operation (Fig.5.3a.). While small trawlers can operate beyond 5 m depth, the other classes of boats can operate safely only beyond a depth of 10 m. The wire rope in the winch will be sufficient to operate up to 50 m for small trawlers and up to 70 m for other class of vessels. The number of days a vessel can stay at sea is based on the capacity of the fuel tank and fresh water tank. The days at sea decided by requirement of water (assuming daily consumption of 40-50 l per person) and fuel (based on average fuel consumption of different classes of vessels) shows that water is a limiting factor (Fig.5.3b.).

The number of days required for the vessels to fill the fish hold depends on the catch rate. Two situations have been assumed to illustrate this factor. In the first situation the catch rate per day has been assumed as 300 kg for small and *Sona* trawlers, 400 kg for mini trawlers and 800 kg for large trawlers. In the second situation, the daily catch rate has been assumed as 500 kg for small, *Sona* and mini trawlers and 1000 kg for large trawlers. The number of operational days needed for filling the hold for small and *Sona* trawlers under both the situations did not vary much. Whereas operational days needed for filling the hold under two situations varied significantly for mini and greatly for large trawlers (Fig.5.3c.).

5.9. Conclusions

The marine fishing sector along the upper East Coast exhibits a diversity of fishing methods, both traditional and modern, which have evolved over the years to effectively capture aquatic organisms. The co-existence of modern, sophisticated

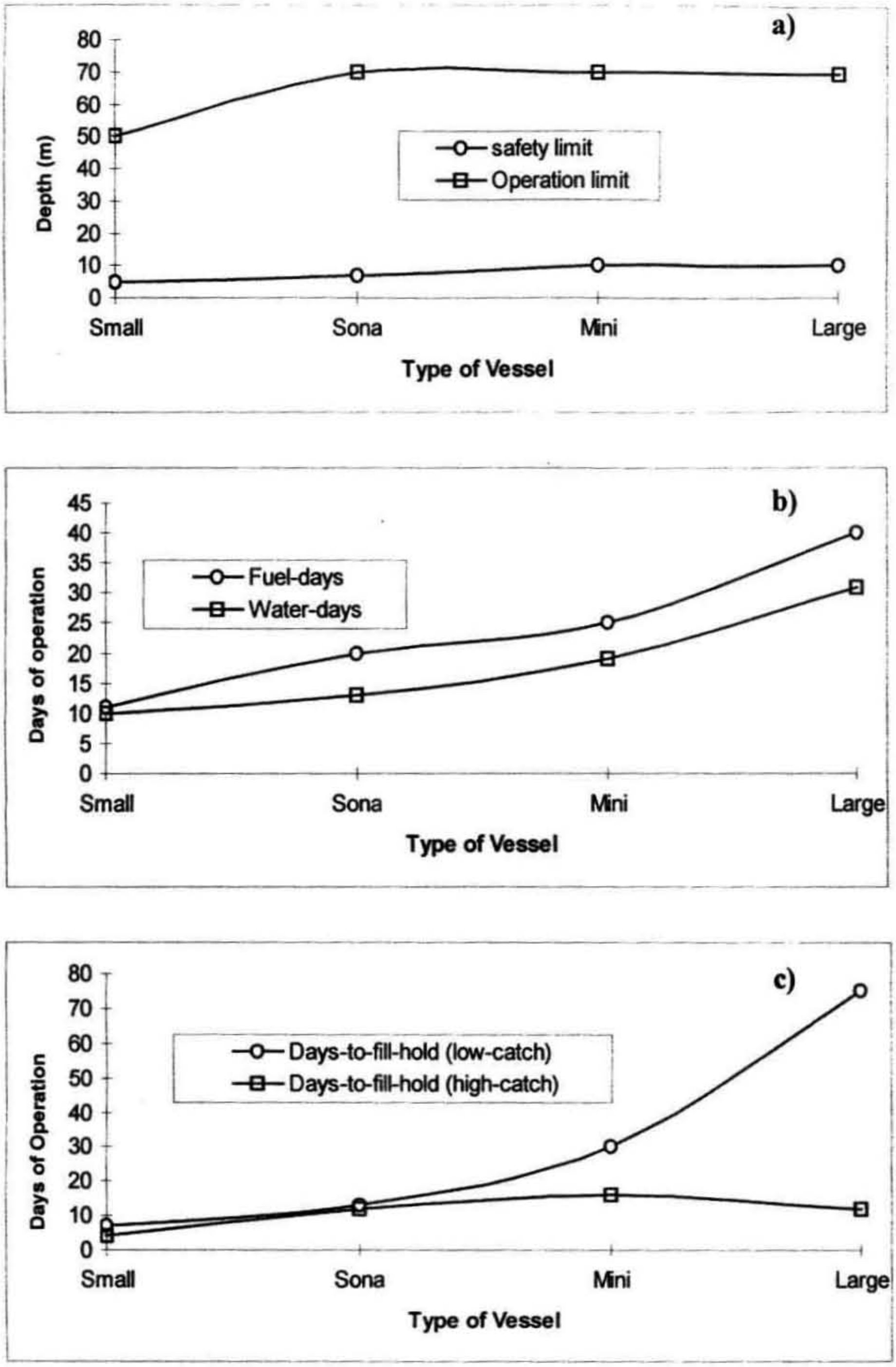


Figure.5.3. The operational limits of different types trawlers a) depth of operation, b) days of operation imposed by fuel and water storage capacity and c) days to attain full fish hold assuming two different catch rates.

mechanized fishing along with traditional techniques based on human power and wind power is a characteristic feature seen in many tropical fisheries of developing countries. While the traditional sector dominate the coast in terms of numbers, the mechanized units account for bulk of the investment in the harvesting sector. Though most of the types of craft/ gear are found in other parts of the country, some are (bag netters, large and mini trawlers etc.) are only found along the upper East Coast. The traditional sector uses different combinations of craft and gear according to the spatial and temporal variations in the sea conditions and species abundance.

The increase in marine fish landings during different periods has come as a result of adoption of new fishing techniques as well as intensification of fishing effort. The fishing technology has shifted towards more power oriented fishing during the past three decades. The dramatic increase in fishing units and gears has caused dwindling of catch rate and lowering of returns per unit. The available fishing capacity is fully utilized by different classes of vessels. Further expansion of fishing effort is not possible due to various limiting factors inherent to the vessels as well as the characteristics of the exploited resources.

While there may be some scope for improving the technology, sustaining the present technology depends on the economic parameters. The volatile market for shrimp and raising cost of inputs, especially fuel, are major concerns posing threat to the sustainability of mechanised fishing. An analysis of market and price of fish as well as an analysis of the economics of operations attempted in the subsequent Chapters will throw more light on this aspect.

CHAPTER – VI

MARKETING AND PRICE OF FISH

CHAPTER – VI

MARKETING AND PRICE OF FISH

6.1. Overview

Marketing of marine fish in India has remained a difficult subject for researchers because of the inherent uncertainties in the supply-demand scenario as well as complexities associated with the channels. During the pre-independence, the domestic marketing of fish was very primitive and exports marketing very limited. During 1946-1961 the Government of India brought out periodic publications on marketing of fish in India, which focussed on mainly freshwater fish (DMI, 1946, 1948, 1951, 1961). Marketing of fish figured prominently in the report of the National Commission on Agriculture (NCA, 1976). The Centre for Management in Agriculture (CMA) of Indian Institute of Management, Ahmedabad (IIMA) has made a comprehensive attempt during early nineteen eighties, which resulted in an eight-volume publication (CMA, 1984). Some authors worked on issues of marketing of marine fish in India (Srinivasa Rao, 1983) and issues related to price policy of fish (Rao, 1971).

There is voluminous amount of literature on marine fish production and supply. Published information on export marketing and trend of marine product exports from India is also abundant. Being a thrust area, the quantum of information available on export promotion and development is also enormous.

Though marketing and price of fish were generally treated along with many other aspects in the literature on fisheries production and development, works focussing on the marine fish marketing along the upper East Coast are very rare compared to the other regions of the country. While Philips (1947) gave some suggestions for improvement of the production and marketing of fish in Bengal, Mitra (1954) discussed the problems of fish marketing in the state of Orissa. There have been many other studies on marketing of fish from localized areas like Visakhapatnam (Subba Rao, 1979) and States like Tamil Nadu (Sathiadas, 1997; Sathiadas and Panikkar, 1988) and Karnataka (Bhatta, 1996). Some authors have paid attention to the role of middlemen in marine fish marketing along Orissa coast (Datta *et al.*, 1988) and different methods of exploitation in fish marketing in Gilakaladindi, Andhra Pradesh (Raju, 2005).

The need for an in-depth study of the price and marketing of marine fish along the upper East Coast is severely felt as a prerequisite for development planning and policy making. Due to the enormous resource requirement to undertake such a study, no agency has so far made any attempt in that direction. A preliminary analysis of the price and marketing of fish along the upper East Coast is attempted here as a minimum requirement to understand the economics of operation of fishing units.

The characteristics of markets and pricing of marine fish are discussed based on the published information as well as personal observations. The ex-vessel price of different varieties of fish collected from Fisheries Harbour at Visakhapatnam during 1995 to 1999 has formed the basis of price analysis. Though the prices of different species varied with time and place, this data is assumed to represent the price structure of marine fish for the whole of the upper East Coast.

The export data of marine products from MPEDA and exchange rate of US $ from RBI were also used for analysis of the export trends and price relations of fish and shellfish. Retail price of fuel (HSD) collected form various sources has been used to analyse the general trend and relations with export price and exchange rates. Standard statistical methods (Snedecor and Cochran, 1953) and software packages were used to analyse the data. Three types of price indices were calculated as detailed in Shepherd (1963). Trend analysis of marine products export was carried out using the methods adopted by Biradar (1999).

6.2. Market Characteristics and Pricing Factors

The supply-demand interaction and several other factors determine price of a commodity in a real market. The case of marine fish is quite unique in the sense that supply-demand –price relations are quite different. There are various factors, which influence the pricing of marine fish. It would be worthwhile to examine the important factors briefly.

6.2.1. Diversity, Uncertainty and Perishability

Marine fisheries in the tropics are supported by a large number of species of different physical, biological and nutritive characteristics. The presence of a heterogeneous assortment of fish widely varying in sizes and taste (biochemical) properties in limited quantities renders the catch unsuitable for supporting any large-scale post-harvest production systems. Therefore baring the exported varieties and limited varieties used for *surumi* production, other species are consumed fresh, dried or used for fishmeal production.

The uncertainty in production is inherent to the tropical fisheries since the dynamic environmental conditions influence the abundance of different species in time and space. Lack of certainty in fish supply and the diversity factor discussed above were identified as the major bottlenecks for establishing an Indo-Australian joint-venture fish-processing unit at Visakhapatnam[1]. The irregular and inadequate supply of

[1] Personal communication from Robert Cordover, Consultant, Hassall & Associates Pty. Ltd.

suitable species of fish has been identified as the major hurdle in sustaining the production of a *surumi* plant located near Visakhapatnam (Vijayakumaran, 1998 [b])

The third important factor is the extreme perishable nature of fish, which necessitates preservation (icing and/or freezing) and storage inevitable for keeping fish longer. The costly and energy intensive processing, storage and preservation are followed for the items that are exported. In the local domestic market, consumers generally prefer fresh fish to iced or frozen fish. Therefore, the demand for frozen fish is very low and there is little premium for preserved fish. The price falls with the increase in duration of storage whereas the cost of preservation increases with the duration, often eating away the margin of profit. In the interior domestic market, marine fish is consumed mainly in dried form. Therefore, much of the fish production is consumed fresh (chilled) or dried.

6.2.2. Infrastructure and Network

Bulk of the marine fish landings take place in small fishing villages dotted along the coastline. Therefore proper preservation and storage are needed for transport to interior markets at longer distances. Though the road connectivity to many important landing centres has developed significantly, small landing places are still not properly connected. The facility for supply of ice, storage and preservation are generally inadequate except at important Fisheries Harbours. The fish catches are daily disposed off at nearby village markets or are dried for sale in the interior markets later.

A good network of private agents connected to various marine products processing and exporting units exists to take care of the export commodities. Prawn, cephalopods and certain species of fish such as seerfish and pomfrets, which fetch better price, are preserved in ice before transport to the processing plants.

6.2.3. Relative Price of Substitutes

Consumers of fish in the coastal belts generally exhibit strong preference to a limited number of species of fish. Most of these 'preferred species' of fish are available throughout the year. Consumers substitute among these preferred species depending on the relative supply and price. In areas nearer to inland water bodies where freshwater fish are supplied regularly, a strong preference to fresh water fish exists. In the interior areas the seasonally abundant marine species, freshwater species as well as dried fish form the components of the consumer's basket. Thus substitution within the basket takes place depending on the prevailing price-species matrix. In the absence of supply of marine fish (as in the case of ban period) the fish eaters go for freshwater species or even dried fish.

Substitution of fish with other meat products is quite unlikely because the price of meat products rarely falls below that of the fish. Generally, consumers of fish are strongly addicted to the flavor of fish for which there is no substitute. However, the facultative consumers who prefer convenience to flavor often shift between poultry meat and fish.

6.2.4. Channels and Efficiency

The marketing channels of marine fish vary from place to place. The simplest being *fishermen-auctioneer-consumer* and a more complex form may be *fishermen - auctioneer – commission agents – wholesaler (processor) - retailer (exporter) - consumer*. The more the number of intermediaries, the less will be the producer's share in consumer's rupee. The pricing of fish, number of intermediaries, marketing margin and the market efficiency are interrelated.

6.2.5. Supply-demand Inequilibrium

The perishable nature of fish coupled with the uncertainty in the quantity and quality of the supply renders the true market pricing mechanism redundant at least in domestic marketing of marine fish. Even when the income of the consumer population increases, the prices tend to stabilize at or near some threshold for most of the species. Thus calculation of elasticity becomes a formidable task in the case of marine fish. While the producer is unable to decide the quantity supplied in response to demand or a price change, the buyers can bargain the price in response to level of supply. In times of plenty there is no incentive for any fisher to postpone the production to another time as the fish left uncaught will be taken by another fisher or may move away to another area or even succumb to natural mortality.

Growth in consumer population has certainly increased the demand and consequently the price of fish. Increase in fishermen population and their gadgets have certainly brought an increase (not proportionate) in production. As a result it could be seen that both supply and prices of fish are increasing. In the coming years, the limiting nature of the fishery resources coupled with changes in the environment could impose restriction on sustained growth of production. At such stage of stagnating production, prices are likely to respond to the increasing demand.

6.3. Price of Fish

The ex-vessel price of fish at Visakhapatnam has shown varying annual patterns during 1995-1999 for different species. The annual average price of different groups of fish is given in Table - 6.1. It could be seen that penaeid prawns fetched highest price because of their export value. The composition of penaeid prawns consisted mainly of tiger, white and brown varieties, the price of which varied. The next

Table - 6.1. Annual average ex-vessel prices (Rupees per kg) of 30 different groups of fish at Visakhapatnam during 1995-1999

Sl.No.	Species	1995	1996	1997	1998	1999	Average
1	*Elasmobranchs*	7	8	8	10	11	8.8
2	*Eels*	9	9	9	9	9	9
3	*Catfishes*	10	11	10	11	17	11.8
4	*Clupeids*	7	7	7	8	8	7.4
5	*Bombayduck*	6	6	8	8	8	7.2
6	*Lizard fishes*	8	9	8	9	11	9
7	*Half beaks and full beaks*	8	9	9	10	12	9.6
8	*Flying fishes*	9	9	10	10	11	9.8
9	*Perches*	22	24	23	25	26	24
10	*Goatfishes*	8	9	9	9	9	8.8
11	*Threadfins*	10	11	6	12	13	10.4
12	*Croakers*	9	9	8	8	9	8.6
13	*Ribbon fishes*	7	6	7	8	8	7.2
14	*Carangids*	8	8	8	8	10	8.4
15	*Silverbellies*	4	4	5	5	6	4.8
16	*Big jawed jumper*	5	5	3	13	12	7.6
17	*Pomfrets*	33	34	32	32	35	33.2
18	*Mackerels*	5	4	10	12	15	9.2
19	*Seerfishes*	35	38	37	39	54	40.6
20	*Tunnies*	8	8	9	10	13	9.6
21	*Bill fishes*	28	31	30	32	40	32.2
22	*Barracudas*	10	10	11	11	13	11
23	*Mullets*	3	3	5	12	10	6.6
24	*Flat fishes*	11	13	13	14	15	13.2
25	*Penaeid prawns*	145	156	159	168	182	162
26	*Non-penaeid prawns*	24	25	26	26	31	26.4
27	*Lobsters*	80	83	79	84	89	83
28	*Crabs*	7	7	6	7	10	7.4
29	*Cephalopods*	28	27	31	33	35	30.8
30	*Miscellaneous*	1	2	2	2	2	1.8

highly priced items were lobsters, seerfishes, pomfrets, billfishes, non-penaeid prawns and perches in that order. Clearly the exported varieties commanded good prices than the non-export varieties. The average unit price of fish has shown a gradual increase during 1995 – 1997 from Rs.15.81 to Rs.16.9 and a rapid increase thereafter to peak at Rs.20.97 in 1999. The abrupt increase in prices in later years could be associated with the establishment of regular supply system to markets in other States. The different indices also reflected the behavior of average unit price (Table - 6.2).

The monthly-pooled average prices varied greatly from year to year (Fig. 6.1a). Though more or less similar monthly trends have been observed during 1995, 1996 and 1997, the two subsequent years have shown altogether different monthly trends. Generally lowest annual average prices were observed during March-May period as well as October – January period.

An estimate of the total value of production form marine fisheries of the upper East Coast has been arrived at by multiplying the group-wise quantity of fish landed by their corresponding ex-vessel price (Fig. 6.1b). The quantity landed during 1995-1999 has increased more or less steadily from around 0.27 million t to nearly 0.35 million t. The estimated total value, on the other hand, has shown a gradual growth during the first three years from Rs.5610 million to Rs.6200 million and then increased at a steeper rate to Rs.9860 million in 1999.

The linear trend line of catch followed closely the observed catch (Fig.6.2a). The annual trends of total value and average unit price were more or less similar (Fig. 6.2b,c). At least during 1996-98 period there seemed to be a slight inverse relation between quantity of fish landed and value realized (Fig.6.2a).

Table - 6.2. Average ex-vessel unit fish price (Rupees per kg) at Visakhapatnam and the three different price indices during 1995-1999

Year	Unit price (Rs. Per kg)	Lapeyres Price index	Passche Price index	Fishers Price index
1995	15.81	100.00	100.00	100.00
1996	16.71	105.27	105.35	105.31
1997	16.90	109.63	109.81	109.72
1998	18.29	116.56	116.40	116.48
1999	20.97	128.85	129.44	129.14

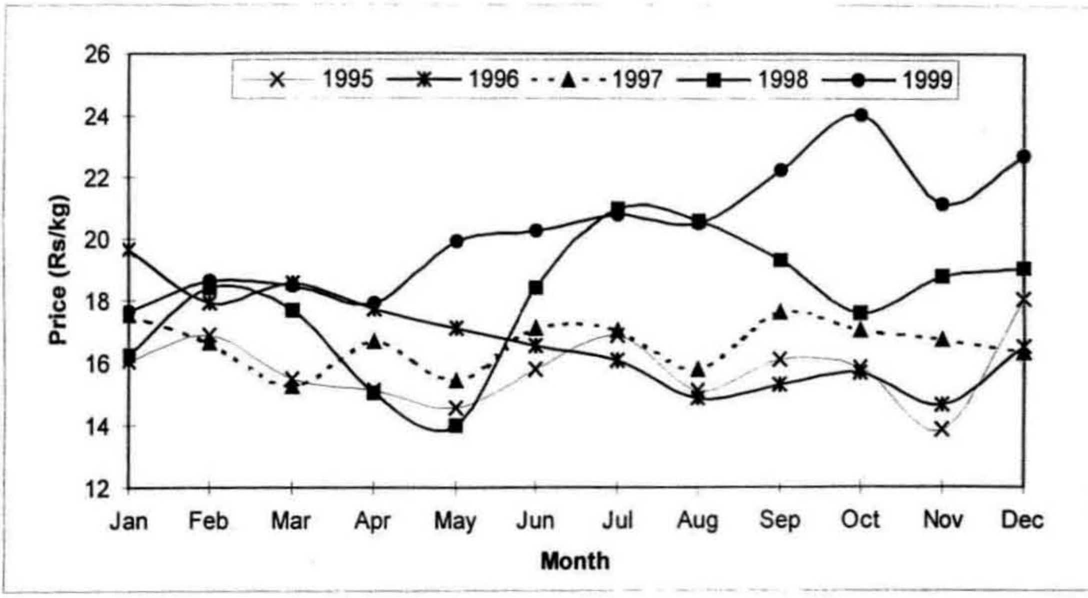


Fig. 6.1a. Monthly pooled average ex-vessel prices of fish at Visakhapatnam during 1995-1999

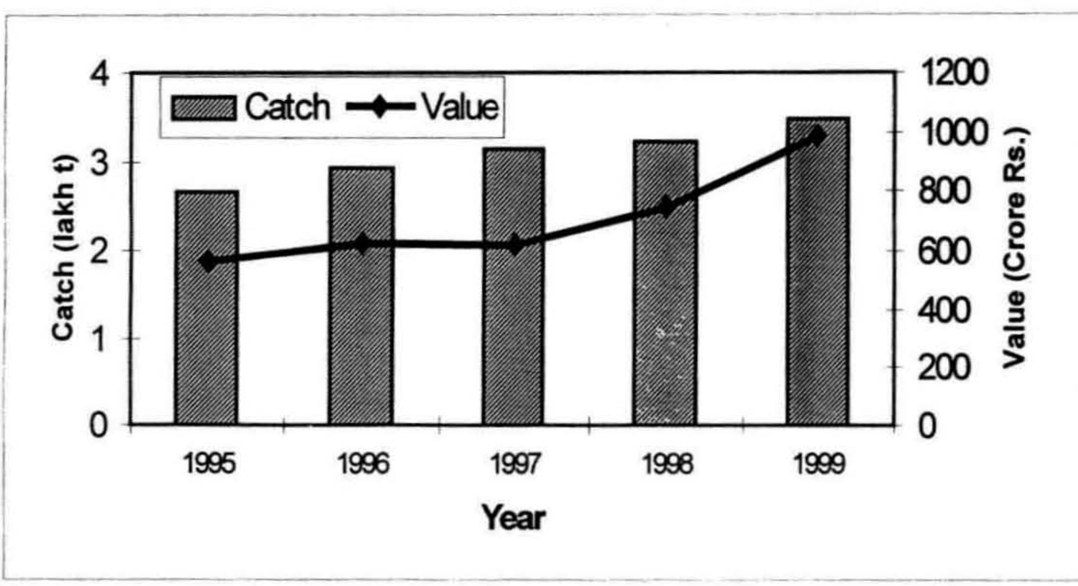
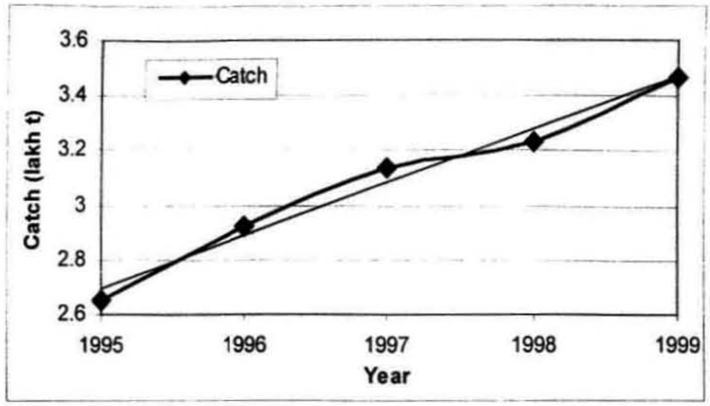
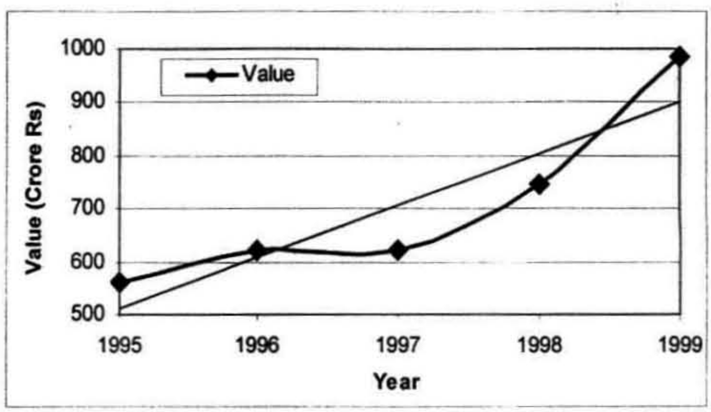


Fig. 6.1b. The trend of total fish landing and estimated total value (based on ex-vessel price at Visakhapatnam) along the Upper East Coast during 1995-1999

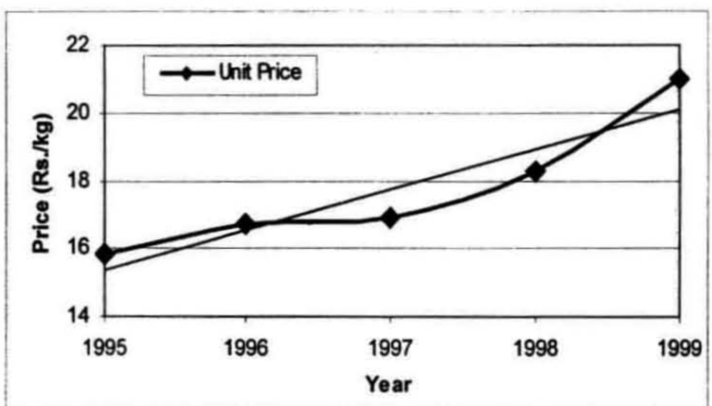
A. Annual trend of catch
$Y = -386.333 + 0.195\,X$,
$(R^2 = 0.978,\ P = 0.001)$



B. Annual trend of total value
$Y = -193483 + 97.241\,X$,
$(R^2 = 0.820,\ P = 0.034)$



C. Annual trend of unit price
$Y = -2358.69 + 1.19\,X$,
$(R^2 = 0.872,\ P = 0.020)$



D. Total value on catch
$Y = -763.564 + 477.3348\,X$,
$(R^2 = 0.768,\ P = 0.051)$

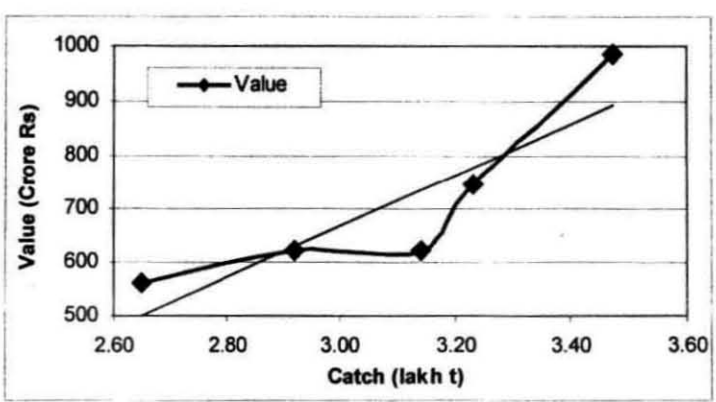


Fig. 6.2. The trend of catch, total value, unit price based on years and total value based on catch

6.4. Export Markets and Prices

The marine fisheries sector is characterized by the dualism of large-scale industrial fisheries and small-scale subsistence fisheries existing side by side (Panayotou, 1985). The development of Industrial fishing being catalyzed by the development of export markets (Vijayakumaran, 1999[a]), the prices of commodities in the export market are the main driver for exploitation of the major target groups of industrial fishing. Therefore the local prices are being influenced by the export market prices directly as well as indirectly. The following discussion on the export trends and prices and their influence on the local prices of fish will throw more light on this aspect.

6.4.1. Trend of Exports and Market Characteristics

Marine product export from the country has shown tremendous growth in terms of quantity, values and the diversity of products during the last four decades. The export grew form 16,337 t valued Rs.40 million in 1960 to 0.42 million t valued at Rs. 64 billion in 2000 with an average of 0.12 million t valued more than Rs.10 million (Fig.6.3a). The unit value realized varied between Rs.2.5 and Rs.152 with an average of Rs.48. The decadal growth in export quantity, value and the unit value from 1960 is summarized in Table - 6.3.

The time series data on quantity and value of export was used to fit five different types of models. The results of regression are provided in Table - 6.4. Of the five different models, the three models: $Y= a+bX +cX^2$, $lnY= a+bX$ *and* $lnY= a+blnX$ have been found to better explain (as indicated by the higher R^2) the trends in price as well as quantity.

The average unit value realized (AUVR) has shown almost a similar trend to that of exchange rate of US $ during the three decades of 1970-2000 (Fig.6.3b). The

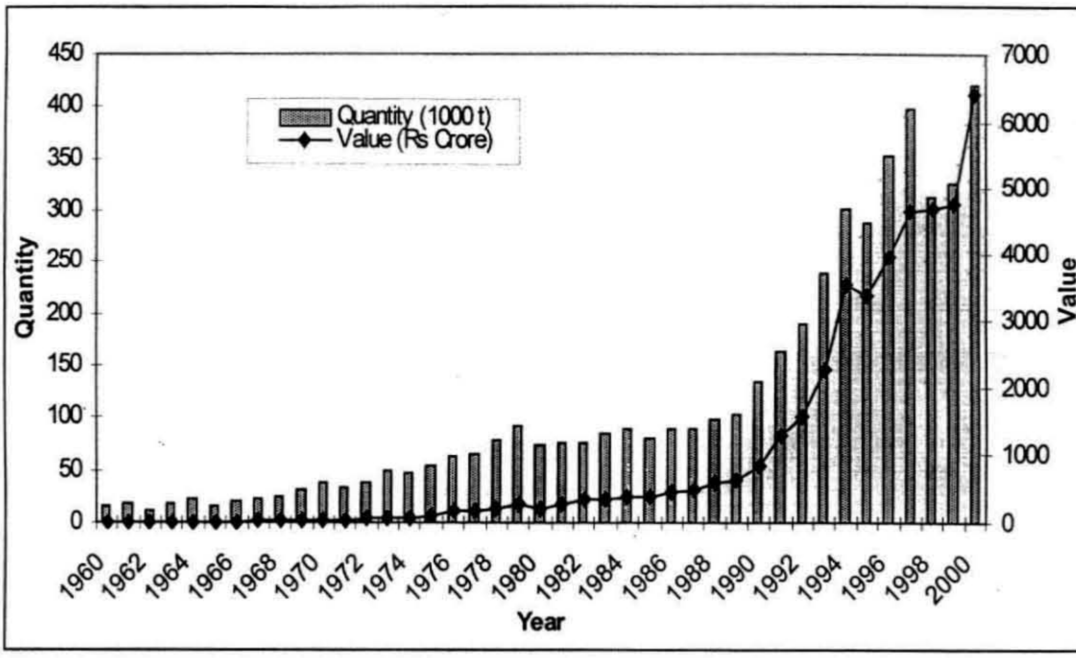


Fig. 6.3a.The trend of marine products exports from India during 1960-2000

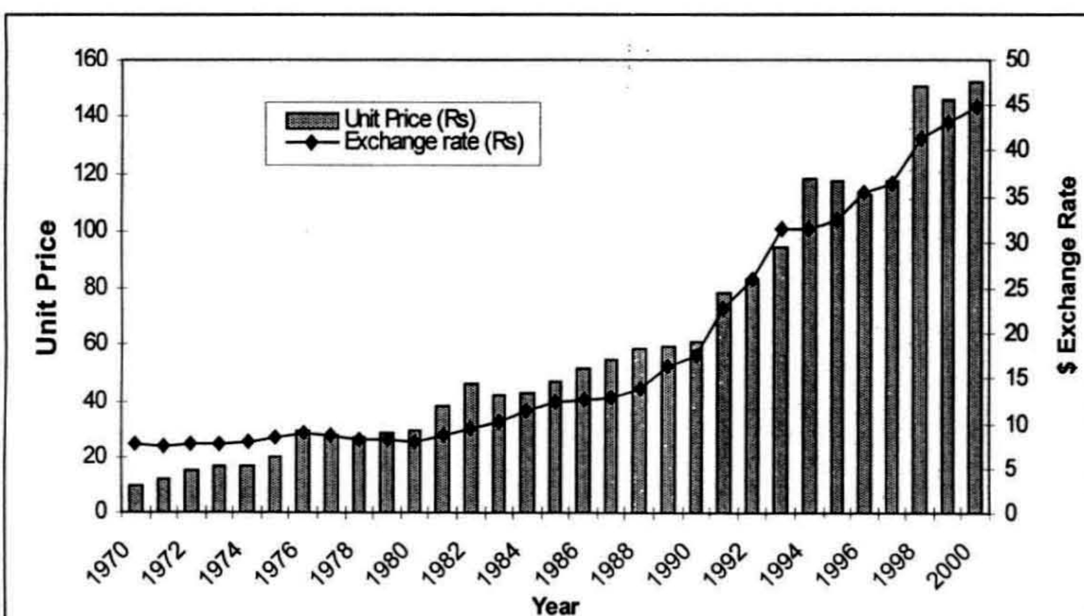


Fig. 6.3b. The trend of price per kg of marine product exported from India and the exchange rate per US$ during the period 1970-2000

Table - 6.3. Growth in marine products exports during five decadal points from 1960

	Decadal Values			Annual Growth		
Year	Quantity (thousand tonnes)	Value (Rs Crore)	AUVR (Rs)	Quantity (%)	Value (%)	AUVR (%)
1960	16.3	4.0	2.5			
1970	37.2	35.5	9.6	12.76	78.36	28.83
1980	74.5	218.9	29.4	10.05	51.59	20.72
1990	133.7	818.4	61.2	7.93	27.39	10.85
2000	421.1	6396.7	151.9	21.51	68.16	14.81

Table - 6.4. Different models depicting the trend of quantity exported (Y_1) and exports value (Y_2) of marine product exports from India.

S. No	Model	Quantity exported (t)	R^2	Value (10^3 rupees)	R^2
1.	$Y = a+bX$	$-2.3 \times 10^7 + 11547.45\,X$	0.79	$-3.4 \times 10^{11} 11 + 1696949\,X$	0.71
2.	$Y = a+bX+cX^2$	$2.42 \times 10^9 - 2454585 + 621.192\,X$	0.93	$4.83 \times 10^{11} - 4.9 \times 10^8 + 123396.3\,X$	0.95
3.	$Y = a+b\ln X$	$-1.7 \times 10^8 + 22901504 \ln X$	0.78	$-2.6 \times 10^{10} + 3.36 \times 10^9 \ln X$	0.71
4.	$\ln Y = a+bX$	$-147.902 + 0.080358\,X$	0.93	$-314.334 + 0.166438\,X$	0.97
5.	$\ln Y = a+b\ln X$	$-1199.26 + 159.4639 \ln X$	0.93	$-2488.52 + 329.7583 \ln X$	0.97

average growth rate of unit value realized during this period has been 10.4 percent. The average appreciation of exchange rate of US $ during the same period has been about 6.4 percent. This indicates that more than 60 percent of the value addition has been due to the effect of depreciation of rupee. Devaluation of Indian rupee against stronger foreign currencies has often given unexpected bonus to the Indian exporters.

The rate of change of AUVR exhibited certain features, which could be related to the change in the composition of the export basket. During the sixties the expansion of industrial shrimp trawling and resultant increase in shrimp component in the export yielded higher AUVR. The seventies and eighties saw gradual introduction of low value items such as fish and reduction in the relative proportion of shrimp in the export basket. This was reflected in the reduction of AUVR during this period. During the nineties, though the trend of increase in non-conventional products continued, their effect in the AUVR was to certain extent nullified by the influx of shrimp from aquaculture.

6.4.2. Export Price and Local Price

In the sixties and seventies, the marine products processing and exporting units have expanded in the country, mainly attracted by the profit margins in foreign exchange and the promotional activities and incentives offered by MPEDA. In subsequent years, the dwindling catches and overcapacity led to tough competition among processors in procuring material for their unit. This development proved to be beneficial to fishing units as they could receive a fair price for their produce, almost in tune with the prices in the export market.

In this competitive market the prices of species that are exported, were influenced to a great extent by their unit value realized in the export market. The ex-vessel prices of selected varieties showed good relationship with the unit value realized as well as the exchange value of US $ (Table - 6.5). It could be noticed that exchange rate and average unit value have been highly correlated with the prices of penaeid prawns and cephalopods, the most important components in the export basket. The quantity of seerfish exported from the upper East Coast is more significant compared to that of pomfrets, which is reflected well in the relationships (Table - 6.5).

6.4.3. Fuel (HSD) Price and Export Price

The retail price of high-speed diesel (HSD) used by the mechanised boats has been showing an ever-increasing trend for several decades (Fig. 6.4a). The year-to-year increase varied from negligible levels (1983 to 1984 and 1994 to 1995) to as high as 44 percent (1980 to 1981). The overall annual average increase in HSD price works out to be 46 percent for the period 1979-2002. Fuel being a critical input, the relations between price of HSD, fish prices and the US $ exchange rate were examined to understand the extent to which prices compensate the cost of fuel.

During 1979-1989 the HSD prices have increased by 139 percent whereas the AUVR and exchange rate increased by 109 percent and 99 percent respectively. During 1989-1999 the HSD prices increase by 211 percent whereas the AUVR and exchange rate increased by 145 percent and 165 percent respectively. There was a strong relation among HSD price, AUVR, the US $ exchange rate and even the local fish price (Fig. 6.4b). The HSD price showed significant correlation with local fish price (r = 0.80), AUVR (r = 0.90) and exchange rate (r = 0.98). The regression of AUVR on HSD price (r^2= 0.924, a: 14.80, b: 10.94) as well as regression of exchange rate on HSD (r^2= 0.916, a: 2.25, b: 3.41) were highly significant.

An increase in fuel price has generally been accompanied by an increase in AUVR and the US $ exchange rate (Fig. 6.4b). However, the rate of increase in fuel price

Table - 6.5. Matrix of correlation among AUVR of export products, exchange value of US $ and average ex-vessel prices (1995-99) of penaeid prawns, lobsters, cephalopods, seerfish and pomfrets.

		Exchange value of US $	*AUVR of export products*	*Ex-vessel Price of*				
				Penaeid Prawns	*Lobsters*	*Cephalo-pods*	*Seerfish*	*Pomfrets*
Exchange value of US $		1	0.90	0.97	0.83	0.91	0.80	0.27
AUVR of export products			1	0.80	0.72	0.87	0.62	0.08
Ex-vessel Price of	*Penaeid prawns*			1	0.87	0.90	0.90	0.43
	Lobsters				1	0.66	0.91	0.73
	Cephalo-pods					1	0.76	0.13
	Seerfish						1	0.74
	Pomfrets							1

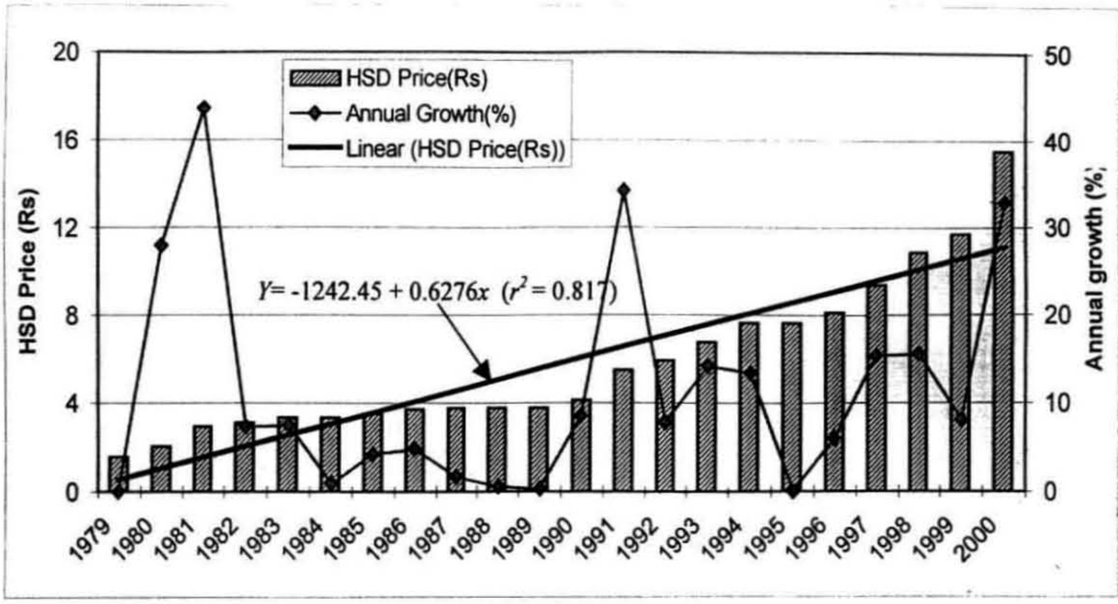


Fig. 6.4a. Annual trend of HSD price at Visakhapatnam during 1979-2000

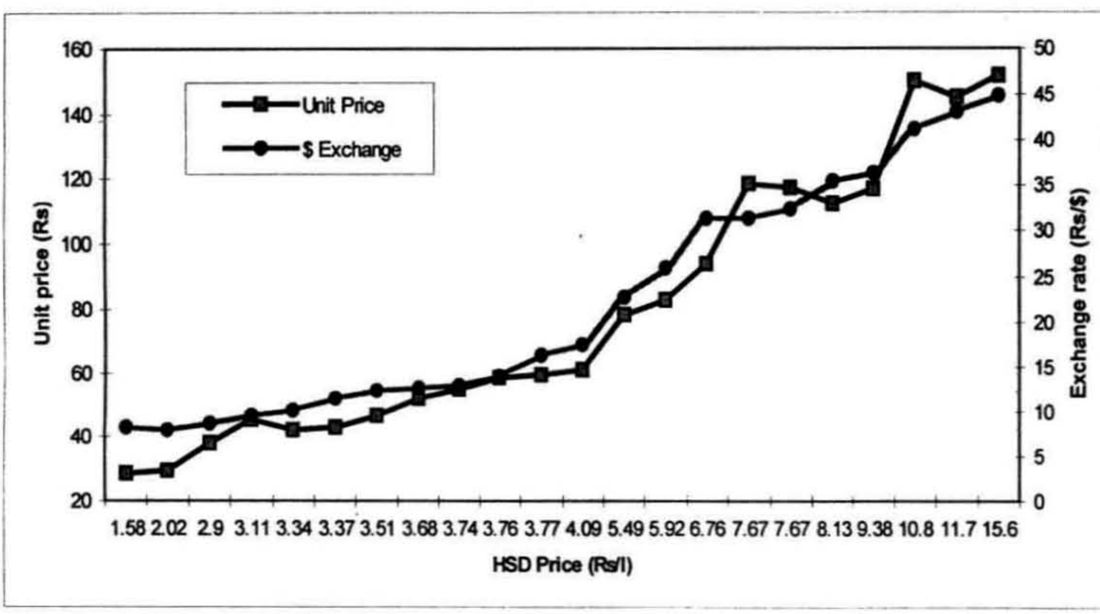


Fig. 6.4b. The variation of unit price (AUVR) of marine product export and the US $ exchange value with change in HSD price during 1979-2000

has been higher than that of AUVR and exchange rate. Since the benefits of increase in AUVR and the US $ exchange rate are not proportionately transmitted down to the primary producers, the fishing units remains at disadvantage forever.

6.5. Conclusions

There are some important conclusions, which could be drawn from the above analysis. The absence of significant studies on the marketing and price mechanism of marine fish along the upper East Coast is a major hurdle in the appraisal of the mechanisms and policy interventions. An in-depth study of the marketing of marine fish along the upper East Coast is therefore felt essential.

Dependency on export markets is one of the weak planks in the sustainability of fishing operations along the upper East Coast. The financial health of the seafood industry has deteriorated over the years. Bhattacharya (2002) mentioned that Indian seafood export industry, dominated by small-scale units has very low level of net worth compared to the high risk it undertakes. Due to this, the industry could not withstand several adverse movements in international fish trade since 1990's. Since almost the entire industry has become sick, it will be incapable to support the dependent primary producers in adverse times.

An important suggestion often given was creation of domestic base for seafood industry to withstand a part of the shocks emanating from the vagaries of the world market (Bhattacharya, 2002). In a similar vein Sathiadas and Kanagam (2000) suggested that a cautious fish marketing policy giving parallel importance to domestic and export marketing should be evolved in the context of liberalisation of economic policies.

Internal markets for marine fish will develop only when the consumers and producers are connected properly. Facilities for better handling and preservation need no emphasis in view of the perishable nature of fish. There is a need for a concerted effort to develop road connectivity and transport infrastructure along the coast. Other infrastructure facilities to help better handling and preservation are also needed for optimum utilization and to prevent post-harvest losses of fish.

Considering the disadvantageous position of the producers in supply-price interaction, some intervention to protect the interests of the small-scale fishermen is felt necessary. As fishing is the livelihood for the small-scale fishermen, an assured return for their produce would certainly ensure their sustenance. Some workers have discussed about minimum support price for fish as given to agricultural commodities (Ramakrishnan, 1981).

As the fishermen's share in consumer's rupee decreases with the number of intermediaries, building and strengthening institutional mechanisms such as cooperative marketing will definitely prove advantageous to the fishermen. This in combination with a cold-chain for storage and retail marketing of fish will definitely improve the situation (Vijayakumaran, 1999[a]).

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CHAPTER – VII

ECONOMICS OF OPERATIONS

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7.1. Introduction

From a mere subsistence activity of the coastal communities before the independence, marine fisheries in India underwent dramatic changes during the post-independence period to become an important economic activity. In the early years, the output of the marine fisheries sector improved as more and more harvesting units were introduced. Attracted by the good returns and profits the investment in fishing units continued leading to over-capitalization in the harvesting sector. Excessive pressure on the resources and sharing of resource rent by a large number of units caused drastic decline in economic efficiency with respect to the output and inputs in fish harvesting.

The prevailing situation in the industry warranted periodic stocktaking, review and revision of policies to sustain the health of the industry. However, such initiatives are yet to find a respectable place in the fishery management system in the country. Development measures to promote quantitative growth often overlooked the various aspects determining the sustainability of the fishery. Viewing the overall health of the sector as indicated by the aggregate of different sub-sectors is often misleading. Unless the sub-sectors are examined separately to derive their salient features, suggesting proper management measures for the entire sector would be difficult.

Economic performance of fishing activities has received relatively little attention along the upper East Coast compared to other three maritime regions of the country. Along the upper East Coast, the biological aspects and stock assessment was the focus of marine fisheries researchers for several decades while socio-economic aspects of fishermen attracted some interest during seventies and eighties. The subject of economic performance of fishing operations gained importance only after the mechanization of fishing boats gained momentum. The public sector banks as well as planning bodies of Government have made some early evaluation of the economic performance of fishing boats (PEO 1971; Syndicate Bank, 1973; BOI, 1986). As deep-sea fishing gained importance in 1970s and 1980s several studies have been made on different aspects of deep-sea fishing vessels (Gokhale, 1971; Raghu Ram, 1971; Perumal, 1973; Dixitulu 1979; Unnithan *et al.*, 1985).

In Andhra Pradesh, Subba Rao (1986) has provided an overview of economics of fisheries (inland and marine). Some works have focussed on specific aspects and areas such as the feasibility of different marine fishing methods at Nizamapatnam (Singh *et al.*, 1987), the case study of impact of mechanization on fishermen at Visakhapatnam (Subba Rao, 1988) and economics of fisheries technologies (Rao and Raju, 1998). While Sehara *et. al.* (1993) analysed the performance of medium and small mechanized trawlers, more recently Raju (2004) studied the interrelationship between various input and output parameters of harvesting units at Gilakaladindi fishing village, Krishna District, Andhra Pradesh.

Along Orissa coast, some workers (Datta *et al.*, 1989[a] and 1989[b]), have made case studies on productivity, profitability, income distribution, and financial feasibility in capture fishery. Studies have also been made on the input-output relationship in capture fisheries (Datta and Dan, 1985) and economics of different craft-gear combinations (Datta *et al.*, 1989[c]). In West Bengal, studies on the comparative efficiency of different craft-gear combinations (Datta and Dan, 1988[a]) and comparative efficiency of different bag nets (Datta and Dan, 1988[b]) have been carried out.

Form the point of sustainability of fishing operations, studies on fuel subsidy (Vijayakumaran, 1992) and the externalities and sustainability (Vijayakumaran, 1998[b]) has addressed some aspects relevant to the upper East Coast. The FAO's workshop on the bio-economics (FAO, 1993) has adopted a more integrated approach but considered only the North-eastern demersal fishery. While Verghese (1994) has confined his techno-economic study to the larger vessels of the upper East Coast, Vijayakumaran (1999[a]) has adopted a slightly broader frame to address the problems and prospects of deep-sea fishing industry. Sehara *et. al.* (1997) has provided a general picture of economic performance of trawl units pertaining to the upper East Coast. A comprehensive study, which considered simultaneously the important sub-sectors of the marine capture fishery along the upper East Coast, have been wanting.

In this Chapter an attempt is made to analyse the various dimensions of economics of operation of important classes of fishing units operating along the upper East Coast as a prerequisite for evolving suitable strategies and management measures for ensuring sustainable exploitation. The results of an analysis of economic performance, productivity and sustainability of important types of fishing units operating along the UEC are presented here.

A preliminary analysis of the catch and effort of different types of fishing units operated along the UEC has been made using the State-wise gear-wise data for 1990-99 from NMLRDC of CMFRI. Analysis of technical, operational and financial aspects of different types of fishing units operating along the upper East Coast has been made using the data collected from questionnaire survey, supplemented with information obtained from different sources.

The economic performance of different types of fishing units has been studied based on the questionnaire survey data. The analysis has been carried out for the following seven categories of fishing units, operated along the entire UEC and represented in all the three maritime States, by selecting a 'purposive sample' (numbers in bracket) from different centres:

i. Large trawlers (15 units)
ii. Mini trawlers (10 units)
iii. *Sona* Trawlers (40 units)
iv. Small trawlers (32 units)
v. Gill netters (22 units)
vi. OBM units (30 units)
vii. Non-mechanised units (34 units)

The operational data pertaining to the period 1998-1999 and 1999-2000 have been considered for the analysis. Conventional methods of financial analysis have been adopted to assess the performance of fishing units. Due to wide disparities observed and non-availability of information on certain variables, the following definitions and assumptions have been made for making different calculations and analyses meaningful.

Depreciation: The life of hull has been assumed to be 20 years for large trawlers, 15 years for all other mechanized units, 10 years for OBM units and 5 years for NM units. The life of engine has been assumed to be 10 years uniformly for all units. The life of all active gears (trawl nets) has been assumed to be two years whereas all passive gears were expected to last for three years. Straight-line depreciation has been calculated based on the assumed life span.

Insurance: Since insurance paid for fishing units varied between 0 to 2 percent, a uniform rate of 1.5 percent has been assumed as insurance premium for all units.

Interest: The capital for investment has been obtained from a wide variety of sources ranging from personal savings to institutional finance. The rate of interest varied with sources as well as borrower, adding to the complexity in evaluation. Therefore, for calculation of interest on capital invested, simple annual rate of 12 percent has been assumed uniformly for all types of vessels.

Opportunity costs: Opportunity costs of labour have been worked out by assuming 250 days normal employment and daily average wage rate of Rs.100 for crew of large and mini trawlers and Rs.70 for the crew of other mechanized units and Rs.60 for OBM and NM units. Opportunity cost of capital has been worked out assuming 15 percent rate of return on capital.

Long-run average economic cost (LRAEC): The costs that includes all the direct expenses and provide a return on fishermen's own labour and capital employed, equal to their opportunity cost has been defined as the long-run average economic cost.

Long-run average financial cost (LRAFC): The cost that includes all of the direct costs, interest and wages paid rather than the opportunity cost has been considered as the long-run average financial cost.

Short-run average cost (SRAC): The cost that covers the entire variable or operational cost (but not the fixed costs) has been taken as the short-run average cost.

7.2. General Trends in Fishing Effort and Catch

The trends in fishing effort and catch varied from gear to gear during different years. Being operational in all the three maritime States of the UEC, the three classes of fishing units namely mechanised trawler (MTN), mechanised gill-netter (MGN) and non-mechanised units (NM) have been treated in detail whereas a general treatment has been made about the other types of fishing units.

7.2.1. Mechanised Trawlers.

Mechanised trawlers (MTN) are the most important fishing units operating along the upper East Coast. The lowest annual average CPUE (254 kg) for MTN has been recorded in Orissa in 1991 and the highest (1547 kg) in West Bengal during 1998. The average CPUE for MTN along the UEC worked out to be 521 kg (Table-7.1). The variation in CPUE as indicated by the standard deviation was highest in West Bengal (s=410) and lowest in Andhra Pradesh (s=95). Except during 1992 and 1993 the trend of CPUE of MTN in Andhra Pradesh was lower than that of West Bengal. The trend of CPUE of MTN in Orissa was below that of Andhra Pradesh throughout the period except in 1999 (Fig. 7.1a).

The annual average CPH varied from 23 kg to 109 kg during 1990-99 with an average of 33 kg for the UEC (Table-7.1). The lowest value was recorded during two years (1994 and 1995) by MTN in West Bengal and in 1999 by the MTN in Andhra Pradesh. An increasing gradient was observed in the average annual CPH of MTN during the 10-year period while moving from Andhra Pradesh towards West Bengal. The CPH of MTN in West Bengal showed great variation (s=36) while that of the Orissa and Andhra Pradesh showed less variation (Fig.7.1b). The CPH in West Bengal reached above 100 kg during 1991 and 1992, plummeted down to below 25 kg in 1994 and remained around 25 kg for the rest of the period.

7.2.2. Mechanized Gill-netter.

Mechanized gill-netters (MGN) are the second important among mechanized category of fishing units operating along the upper East Coast. The lowest annual average CPUE of 28 kg for MGN was recorded in Andhra Pradesh in 1992 and the highest CPUE of 1347 kg in West Bengal during 1997. The annual average CPUE

Table - 7.1. The range, average and standard deviation of CPUE and CPH (kg) worked out for different class of fishing units along the upper East Coast during 1990-1999.

GEAR		Minimum	Maximum	Average	Std-dev.
Mechanised trawlers	*CPUE*	254	1547	521	138
(MTN)	*CPH*	23	109	33	4
Mechanised gill-netter	*CPUE*	28	1347	180	51
(MGN)	*CPH*	6	41	19	3
Mechanised bag-netter	*CPUE*	336	1202	654	306
(MBN)	*CPH*	20	131	63	35
Other mechanised units	*CPUE*	5	741	169	103
(MOTHS)	*CPH*	1	122	16	9
OB Motorised boat-seiner	*CPUE*	85	933	237	309
(OBBS)	*CPH*	37	252	60	80
OB Motorised gill-netter	*CPUE*	24	193	83	53
(OBGN)	*CPH*	3	36	14	5
Other OB motorised units	*CPUE*	22	2833	223	209
(OBOTHS)	*CPH*	35	1044	51	67
Non-mechanised units	*CPUE*	20	177	51	16
(NM)	*CPH*	6	30	14	6

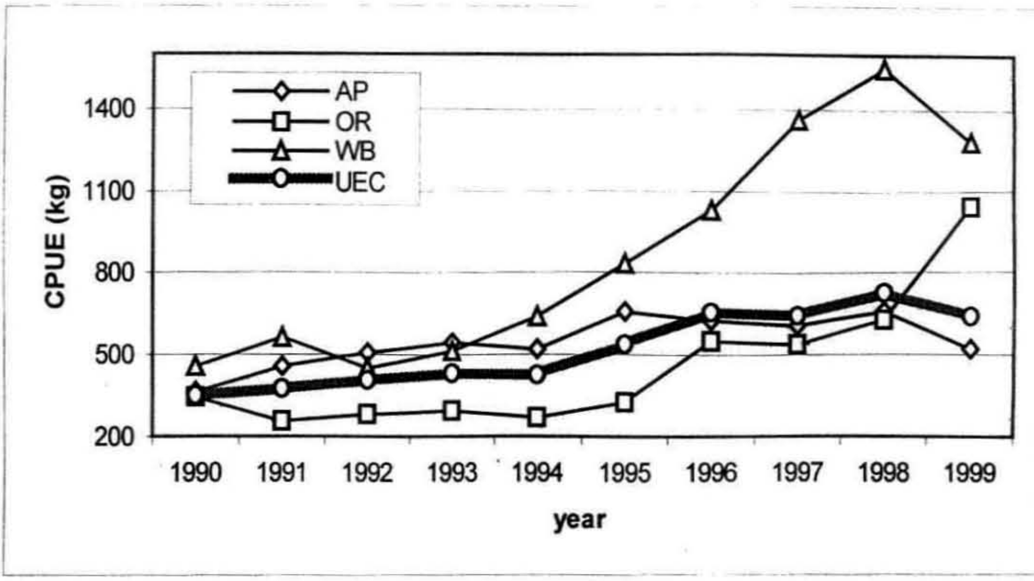

Fig. 7.1a. The trend of catch per unit effort (CPUE) of mechanized trawl net (MTN) along the different states of the upper East Coast during 1990-1999.

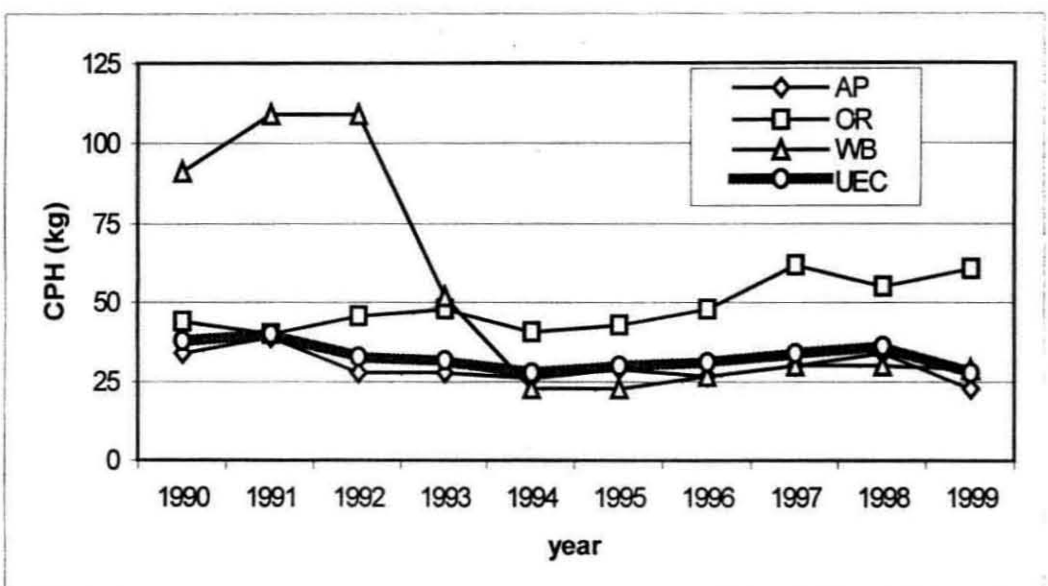

Fig. 7.1b. The trend of catch per hour (CPH) of mechanized trawl net (MTN) along the different states of the upper East Coast during 1990-1999.

for the UEC worked out to be 180 kg (Table-7.1). The variation in CPUE as indicated by the standard deviation was very high in West Bengal (s=282) compared to Orissa (s=24) and Andhra Pradesh (s=31). The trend in CPUE of MGN in Andhra Pradesh and Orissa remained below 300 kg and that of West Bengal above 300 kg throughout the period (Fig. 7.2a).

The annual average CPH of MGN varied from 6 to 41 kg during 1990-99 with an average 19 kg for the UEC (Table-7.1). Andhra Pradesh and Orissa incidentally recorded the same average CPH of 16 kg. West Bengal on the other hand, recorded a much higher CPH of 25 kg at a higher variation (Fig.7.2b).

7.2.3. Non-mechanised Units.

Non-mechanized units (NM) are the most numerous and the mainstay of the traditional sector along the upper East Coast. The lowest annual average CPUE of 20 kg for NM units was recorded in Andhra Pradesh in 1994 and Orissa in 1997. The highest annual average CPUE of 177 kg was recorded in West Bengal during 1993. The annual average CPUE of NM units along the UEC worked out to be 51 kg during 1990-1999 (Table-7.1). The variation in CPUE as indicated by the standard deviation was high in West Bengal (s=36) followed by Andhra Pradesh (s=21) and Orissa (s=6). The trend in CPUE of NM units in Andhra Pradesh and Orissa remained below 100 kg throughout the period whereas that of West Bengal was above 100 kg up to 1996 and below 100 kg during 1997-1999 (Fig. 7.3a).

The annual average CPH for NM units varied from 5 to 30 kg during 1990-99 with an average 14 kg for UEC (Table-7.1). The average CPH was highest in West Bengal (20 kg) followed by Andhra Pradesh (16 kg) and Orissa (7 kg). The trend in average annual CPH in West Bengal fluctuated widely whereas the CPH was more

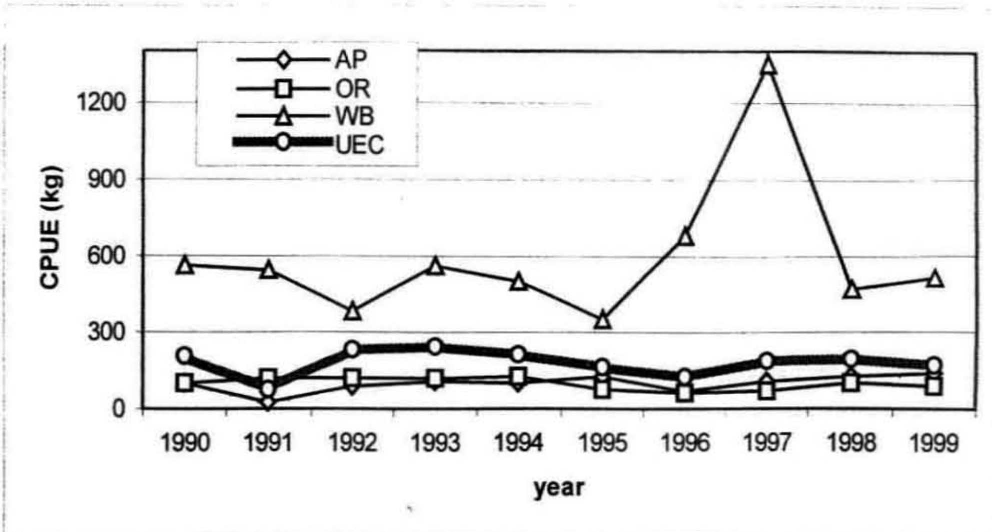

Fig. 7.2a. The trend of catch per unit effort (CPUE) of mechanized Gill net (MGN) along the three states of the upper East Coast during 1990-1999.

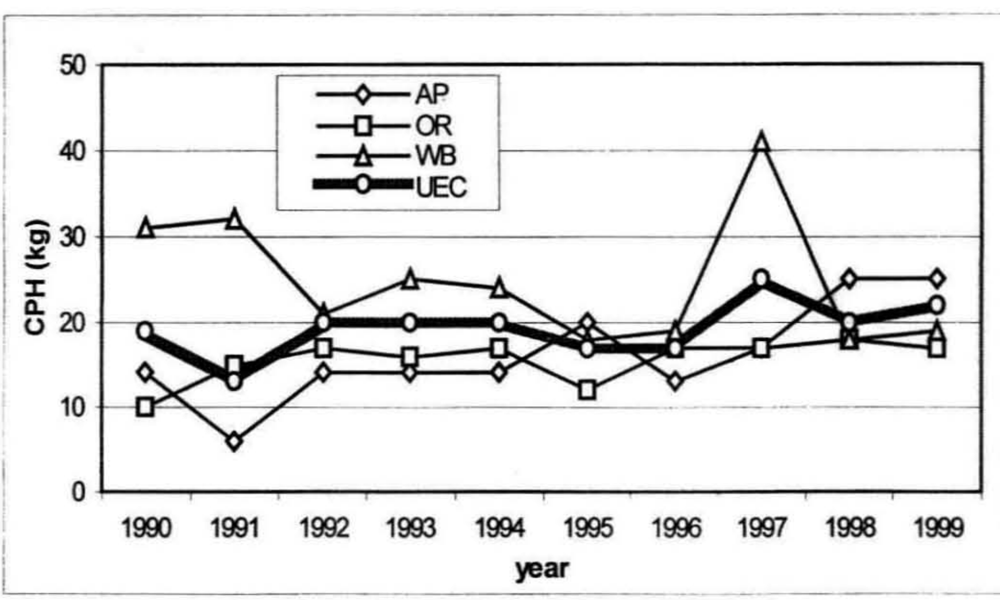

Fig. 7.2b. The trend of catch per hour (CPH) of mechanized Gill net (MGN) along the different states of the upper East Coast during 1990-1999.

or less stable in Orissa and increased steadily in Andhra Pradesh during 1995- 1999 period (Fig. 7.3b).

7.2.4. Other Units.

Mechanized bag-netters, a dominant fishing fleet in West Bengal, recorded an average CPUE and CPH of 654 kg and 63 kg respectively with wide variations (Table-7.1). Other mechanized gears recorded an average CPUE and CPH of 169 kg and 16 kg respectively. Outboard-motorized (OBM) boat seine units operated mainly in Andhra Pradesh recorded annual average CPUE and CPH of 237 kg and 60 kg respectively. While OBM gill-netters recorded a CPUE of 83 kg at a CPH of 14 kg, other OBM units recorded a CPUE of 223 kg at a CPH of 51 kg (Table-7.1).

The above figures derived from the NMLRDC data are indicative of the average performance of various classes of fishing units in the recent past. Considering the increase in effort and decline in catch in subsequent years, the maximum of CPUE and CPH indicates achievable limit under the existing scenario. Comparing with these figures the results derived from the survey data, presented in a subsequent section, indicate a general reduction in CPH for all units surveyed.

7.3. Strategies and Key Factors of Fishing

The fishing units operating along the UEC have adopted different strategies of operations depending on some key factors. The strategies show spatial and temporal variations even within the same class of vessels. While mechanised trawlers, especially the *Sona* boats are the most adaptive, non-mechanised units were, by and large, unable to change their strategies under the changed scenario. The key factors influencing the fishing operations are worth examining.

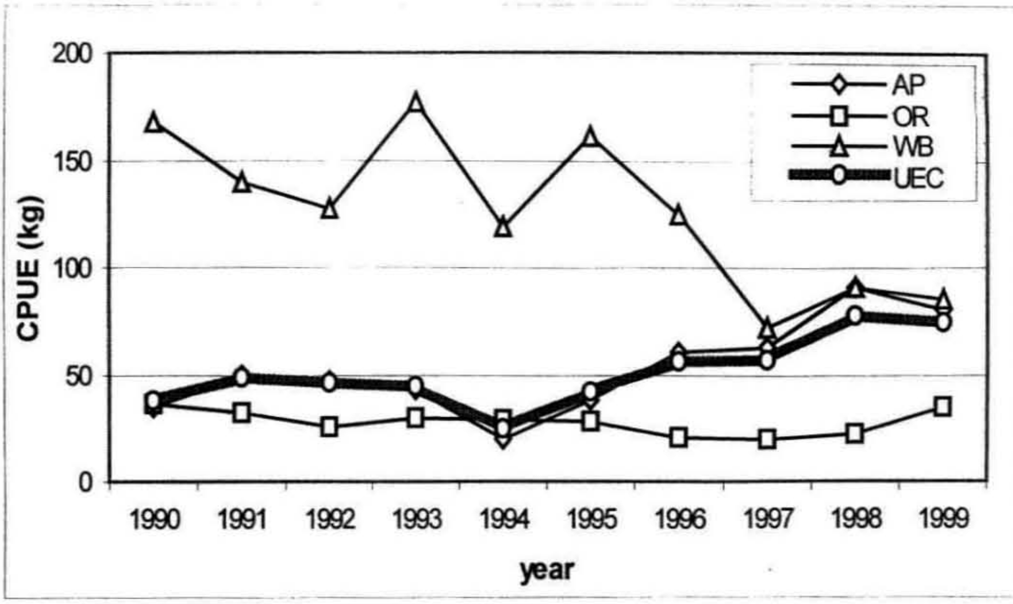

Fig .7.3a. The trend of catch per unit effort (CPUE) of non-mechanized gears (NM) along the three states of the upper East Coast during 1990-1999.

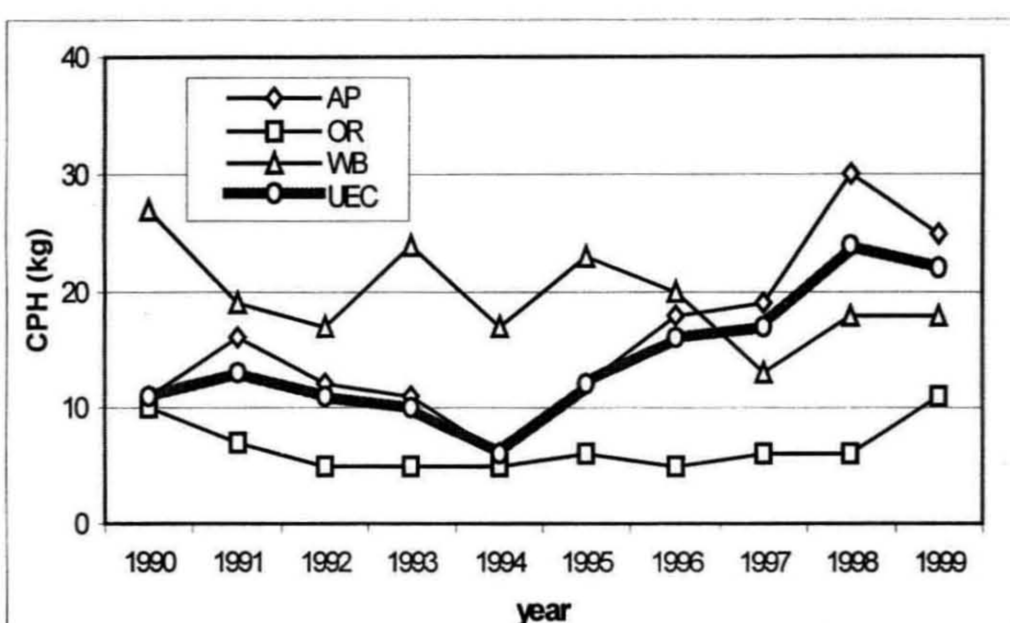

Fig. 7.3b. The trend of catch per hour (CPH) of non-mechanized gear (NM) along the different states of the upper East Coast during 1990-1999.

The economic viability of fishing units depends mainly on the surplus income earned from the operational output over the cost of inputs. But unlike most other business entities, fishing units have to face a different set of factors, many of them uncontrollable. In the context of discussing efficiency of small-scale fisheries operations, Kurien (1998) classified these factors as nature-determined and work-determined.

The resource base on which the units depend is beyond the visual realm and therefore it is not amenable to direct quantification or estimation. In addition, the variability caused by several natural phenomena and the dynamics of a typical common property natural resource render the operational planning of fishing units difficult with a high degree of risks and uncertainty. However, fishermen often adopt exploitation strategies with respect to some factors, so as to ensure better return from fishing during a given period.

7.3.1. Distance to the ground

The distance to the fishing ground, a crucial factor affecting the economics of operations of a vessel, varies with the type of crafts and resources exploited (Table-7.2). Gears like shore seines are operated right form the beaches (Plate-10). Traditional fishing vessels generally operate within 10 km from the shore, though some units, especially hooks and line fishing craft may go farther up to 16 km. The OBM crafts venture on an average to 20-25 km from the shore whereas the inboard-motored shark fishing crafts may go far into the open sea, staying for a couple of days at sea.

The mechanized gill-netters doing stay fishing along the upper East Coast on an average go up to 80 km though they confine within for 30 km for daily operation. Small-mechanized trawlers operating daily trips do not venture beyond 50 km, whereas those doing stay fishing operate up to 200 km. The average distance to the grounds for *Sona* boats is 144 km whereas their range of operations is between 45 to 350 km. Mini trawlers on an average operate at about 300 km whereas large trawlers operate at an average distance of 338 km (Table-7.2).

7.3.2. Crew Strength

The type of fishing operation decides the manpower requirement and the accommodation available onboard limits the number of crew in a fishing unit. Except trawlers, which use mechanical power to shoot and haul the net, all other types of fishing units depend on human power for shooting and hauling of nets. The average crew strength ranges from 4 in non-motorised units to 14 in large trawlers (Table-7.2). Though the strength of the crew is a key factor to production, there is seldom a situation of shortage of crew.

7.3.3. Duration of Fishing

The annual average number of sea days ranged from 177 for mechanized gill-netters to 231 days for large trawlers. The annual average number of fishing days on the other hand varied between 134 for gill-netters and 200 days for large trawlers (Table-7.2). The number and duration of voyages undertaken by the units together with the distance to the grounds determines the fishing days and sea days for a given class of vessel. While the sea days and fishing days are same for those units, which undertake daily trips, the difference between sea days and fishing days for other classes of vessels represent the days spent on cruise between port and grounds (Table-7.2).

The average number of hours spent on fishing operation in a day again depends on the duration of the voyage. The units going for daily fishing operations have to

Table - 7.2. The summary of fishing operations for different classes of fishing units selected for the study

Average of factors	Large Trawler	Mini Trawler	*Sona* Trawler	Small Trawler	Gill-netter	OBM Units	NM Units
Number of crew	14	11	8	6	7	5	4
Distance to ground (km)	338	300	144	87	52	11	6
Total sea days	231	207	211	185	177	179	193
Total fishing days	200	173	176	156	134	179	193
Number of voyages	4	9	35	82	29	179	193
Days of voyages	57	24	7	3	6	1	1
Fishing days per voyage	50	19.2	5	1.9	4.6	1	1
Fishing hours per day	20	20	19	17	18	7	5
Total fishing hour	4000	3460	3344	2652	2412	1253	965
Total catch (tonnes)	91.8	73.0	104.0	67.8	29.1	14.2	4.9
Total revenue (Rs.1000)	8915	2683	1621.2	1106.9	705.6	238.2	73.3
Catch per sea day (kg)	397.3	352.7	493	366.6	164.3	79.1	25.3
Catch per day (kg)	458.8	422	591.1	434.7	217	79.1	25.3
Catch per hour (kg)	22.9	21.1	31.1	25.6	12.1	11.3	5.1
Revenue per sea day (Rs.)	38593	12961	7683	5983	3986	1331	380

naturally limit fishing hours. It could be seen that all mechanized units on an average operate their gears for 17-20 hours a day. The traditional NM units and the OBM units on the other hand carry out fishing operations for an average 5 and 7 hours respectively (Table-7.2.) Altogether the mechanized units have expended higher fishing hours (between 2400 and 4000 hrs) compared to the NM units and the OBM units.

7.4. Economics of Operations

The economic performance of different types of vessels depends on the capital investment, fixed expenditure, operational expenditure and revenue generated during operations. A brief discussion of the four different components is a prerequisite to understand the economics of operation of fishing units along the UEC.

7.4.1. Capital Investment

The capital investment in fishing units varies with the degree of sophistication of fishing technology. At one extreme, the large mechanized trawlers had an average investment of Rs.11 million and at the other extreme, the average investment in traditional NM units was less than 50 thousand. The vessel (hull) and gear are the two important components of the capital investment for all types of fishing units. The engine is the second important component of investment in all mechanised and motorised units. Investment in other accessories, equipments and gadgets varies with the types of vessel and even within the same type there will be disparities. Therefore, the fourth component, collectively named 'others', has been clubbed with the investment on vessel for convenience of analysis.

Except traditional non-motorised units, the investment in vessel hull was the highest component, which accounted for 42 percent in OBM vessels and 73 percent in large trawlers. In the case of traditional NM units, the gear accounted for 55 percent of the investment. In the case of mechanised and motorised units, the cost of engine accounted for 19 to 34 of the total investment. The percentage investment in different components of *Sona* trawlers, small trawlers and gill-netters were more or less similar, obviously due to their similarity in size and engine power. The break-up of investment in different components with respect to the seven types of fishing units selected for the study would give a relative picture (section A, Table-7.3).

7.4.2. Fixed Expenditure

The fixed expenses consist of interest on capital, depreciation (of vessel, engine and gear), insurance and overhead expenditure. The fixed cost varied from less than Rs.20 thousand for NM units to over Rs.3 million for large trawlers (Section B, Table-7.3). For all mechanized trawlers interest on capital (accounting for 29-43 percent) and overhead and establishment charges (accounting for 25 to 31 percent) were the two important components of the fixed cost. For gill-netters, OBM units and NM units, interest on capital (29-43 percent) and depreciation on gear (19 to 46 percent) were the important components of the fixed cost. The fixed cost formed between 23 to 35 percent of the total cost in the case of mechanized and motorized units while it formed about 78 percent of the total cost of NM units.

7.4.3. Operational Expenditure

The running, operational or variable costs are the most important components affecting the short-run feasibility of the fishing units. The annual average operational costs varied between Rs.5300 for NM units to Rs.5.7 million for large trawlers (Section C, Table-7.3). The major heads of operational expenditure for

Table - 7.3. The financial summary (figures in 1000 rupees) of different types of fishing units along the UEC.

Particulars	Large Trawler	Mini Trawler	*Sona* Trawler	Small Trawler	Gill-netter	OBM Units	NM Units
A – Investment							
Vessel	8041	2021	523.8	331	304.3	95.6	21.6
Engine	2600	681	335	161	140	37.9	-
Gear	333	168	138	99.8	85	62.1	26.4
Total	**10974**	**2870**	**996.8**	**591.8**	**529.3**	**195.6**	**48**
B - Fixed Costs							
Depreciation -vessel	402.1	133.4	34.6	21.8	20.1	9.6	4.3
Depreciation -engine	260	68.1	33.5	16.1	14	3.8	-
Depreciation -gear	166.5	84	69	49.9	28.1	20.5	8.7
Interest on capital	1316.9	344.4	119.6	71	63.5	23.5	5.8
Insurance	159.6	40.5	12.9	7.4	6.7	2	0.3
Overhead & establishment	749	244	112.1	75.3	14.5	-	-
Total	**3054.1**	**914.4**	**381.7**	**241.5**	**146.9**	**59.4**	**19.1**
C - Operational costs							
Fuel and lubricants	3368	1332	844.2	530.9	235.7	70.6	-
Water and ice	26	128.5	73.9	47.4	72.9	4.1	-
Charges and fees	50	30	4.1	3.3	2.5	0.1	0.1
Wages	456	154	60.7	19.7	85.4	19.5	-
Food	110.2	93	43.7	27.6	32.9	-	-
Repair and maintenance	1441	429	129.6	66.6	44.4	8.3	1.1
Gear replacement	166	101	45.5	39.9	17	9.9	3.7
Miscellaneous	62	25	31	22.2	5.9	0.8	0.4
Total operational cost	**5679.2**	**2292.5**	**1232.7**	**757.6**	**496.7**	**113.3**	**5.3**
Total Cost	**8733.3**	**3206.9**	**1614.4**	**999.1**	**643.6**	**172.7**	**24.4**
D - Revenue							
Sale of prawn	7023	2027	930	608	-	30.6	20.1
Sale of fish	1892	657	680	484.9	705.6	207.7	53.2
Others	-	-	12	14	-	-	-
Total	**8915**	**2683**	**1621.2**	**1106.9**	**705.6**	**238.2**	**73.3**
Less incentive	-694	-188	-165.2	-118.8	-46	-23.6	-35.9
Net Revenue	**8221**	**2496**	**1456.8**	**988.1**	**659.6**	**214.7**	**37.4**
E – Profitability							
Operating profit	2541.8	203.5	224.1	230.5	162.9	101.4	32.1
Net profit (loss)	-512.3	-710.9	-157.6	-11	16	42	13
Surplus >VC +12% ROI	1224.9	-140.9	104.4	159.5	99.4	77.9	26.3

different types of fishing units varied with the degree of sophistication of fishing. Fuel and lubricants was the major head accounting for 47 to 70 percent of the operational expenses of mechanized and OBM units. Repair and maintenance, which accounted 9 to 25 percent was the second major item for trawlers. Wages, forming 17 percent, was the second important head of the operational costs for gill-netters and OBM units. For NM units, gear replacement (70 percent) and repair and maintenance (21 percent) were the major heads of operational costs. The operational cost formed between 66 and 76 percent of the total costs of mechanized and OBM units whereas in the case of NM units it formed only 22 percent of the total cost.

7.4.4. Revenue

Revenue earned by the fishing boats could be identified under two heads namely sale of prawns and sale of fish. A third component 'other', which is not significant on an average, indicates capture and sale of 'tiger prawn brooder', in which only a few small and *Sona* trawlers surveyed were involved. The total annual revenue varied between Rs.73 thousand for NM units and Rs.8.9 million for large trawlers (Section D of Table-7.3). Among the trawlers the contribution of prawns varied between 55 percent for small trawlers to 79 percent for large trawlers and that of fish varied between 21 percent for large trawlers and 44 percent for small trawlers. The relative contributions of prawn and fish were more or less similar between the large and mini trawlers and between *Sona* and small trawlers.

The incentive system being practiced by most of the fishing vessels is based on the income. The share of revenue given as incentive for crew varied with type of vessels, ranging between 7 and 11 percent among mechanized and OBM units while forming nearly 50 percent in the case of NM units. The incentive has been accounted at the income level to arrive at the net income. The net income thus is about 7-10 percent less for all vessels except the NM units in whose case it is less by about 50 percent.

7.4.5. Profitability

The operating profit for all types of vessels is positive indicating that on the average they are able to meet their running expenditure. The annual operating profit ranged from Rs.32 thousand for NM units to Rs.2.5 million for large trawlers (Section E of Table-7.3). When it comes to net profit, all the trawlers indicated negative profit. While gill-netters managed a marginal profit, the OBM and NM units were better off considering their scale of operation. As a safe margin of operation, surplus over operating profit and 12 percent return on investment (ROI) has been worked out. The results were comfortable for all types of vessels except mini trawlers. Thus mini trawlers represent the most affected class of vessels among the lot.

7.4.6. Harvesting Cost Per Sea Day

Harvesting cost per sea day has been worked out for different types of fishing units to obtain the relative picture of contribution of different cost heads to the daily total cost of fish harvesting (Table-7.4). For all mechanized and OBM units fuel cost accounts for 46 to 64 percent of the daily harvest cost. It is worth noting that the fuel cost for gill-netters was lowest since they are engaged in passive fishing and mostly use power for only running the vessel. Compared to *Sona* and small trawlers, large and mini trawlers were able to reduce their fuel cost by nearly 10 percent partially by resorting to longer voyages and partially by deep-sea bunkering.

For large mini and *Sona* trawlers, repair and maintenance was the second important head followed by establishment charges. For gill-netters and OBM units, wages accounted for the second important head. For traditional NM units, gear

Table - 7.4. The average harvesting costs (rupees per sea day) worked out for different classes of fishing units selected for the study

Particulars	Large Trawler	Mini Trawler	*Sona* Trawler	Small Trawler	Gill-netter	OBM Units	NM Units
Fuel and lubricants	14580 *(52)*	6435 *(53)*	4001 *(63)*	2870 *(64)*	1332 *(46)*	394 *(62)*	-
Water and ice	113 *(<1)*	621 *(5)*	350 *(5)*	256 *(6)*	412 *(14)*	23 *(4)*	-
Charges and fees	216 *(1)*	145 *(1)*	19 *(<1)*	18 *(<1)*	14 *(<1)*	1 *(<1)*	1 *(4)*
Wages	1974 *(7)*	744 *(6)*	288 *(5)*	106 *(2)*	482 *(17)*	109 *(17)*	-
Food	477 *(2)*	449 *(4)*	207 *(3)*	149 *(3)*	186 *(6)*	-	-
Repair & maintenance	6238 *(22)*	2072 *(17)*	614 *(10)*	360 *(8)*	251 *(9)*	46 *(7)*	6 *(21)*
Gear replacement	719 *(3)*	488 *(4)*	216 *(3)*	216 *(5)*	96 *(3)*	55 *(9)*	19
Miscellaneous	268 *(1)*	121 *(1)*	147 *(2)*	120 *(3)*	33 *(1)*	4 *(1)*	2 *(7)*
Establishment	3242 *(12)*	1179 *(10)*	531 *(8)*	407 *(9)*	82 *(3)*	-	-
Total	**27827**	**12254**	**6373**	**4502**	**2888**	**632**	**28**

Figures in bracket: percentage of the total replacement accounted for 68 percent of the daily harvesting cost followed by repair and maintenance. The average daily total harvesting cost varied between Rs.28 for NM units and Rs.28,000 for large trawlers (Table-7.4).

7.4.7. Financial Ratios

The financial performance indicating the economic efficiency of different types of fishing units has been examined by working out the important financial ratios (Table-7.5). The high gross ratio (GR) of all mechanized units indicates the excessive cost of operation in relation to revenue. The ratio exceeding one in the case of mini trawlers indicates the inadequacy of income to meet the total cost. The lowest GR of NM units and relatively lower GR of OBM units indicate the degree of leverage these units enjoyed. The operating ratio (OR) indicated the degree to which the returns are capable of meeting the operating or variable costs. The OR for all mechanized units varied between 0.64 and 0.85 indicating a tight position (Table-7.5). The OBM units were much better off with relatively lower OR of 0.48 while the NM units were really comfortable with a lowest OR of 0.07. The fixed ratio (FR) relates the gross revenue to the fixed costs. While the large and mini trawlers had similar FR of 0.34, the FR of other categories of units varied closely between 0.21 and 0.26.

Operating profit being positive for all units, the ratio of operating profit to variable cost was also positive and ranged between 0.09 for mini trawlers and 6.06 for NM units. The net profit being negative for all trawlers, the ratios involving net profit were negative for trawler units and positive for the other type of units (Table-7.5). Similarly capital recovery factor and cost recovery factor were negative for trawlers and positive for other units indicating the relatively bad overall state of industrial trawl fishing.

Table - 7.5. The different financial ratios based on average financial results for different classes of fishing units selected for the study

Particulars	Large Trawler	Mini Trawler	*Sona* Trawler	Small Trawler	Gill-netter	OBM Units	NM Units
Total cost to gross revenue (GR)	0.98	1.2	1	0.9	0.91	0.73	0.33
Variable cost to gross revenue (OR)	0.64	0.85	0.76	0.68	0.7	0.48	0.07
Fixed cost to gross revenue (FR)	0.34	0.34	0.24	0.22	0.21	0.25	0.26
Variable cost to net profit	-11.09	-3.22	-7.82	-68.87	31.04	2.7	0.41
Operating profit to variable cost	0.45	0.09	0.18	0.3	0.33	0.89	6.06
Net profit to gross revenue	-0.06	-0.26	-0.1	-0.01	0.02	0.18	0.18
Net profit to variable cost	-0.09	-0.31	-0.13	-0.01	0.03	0.37	2.45
Capital recovery factor	-0.05	-0.25	-0.16	-0.02	0.03	0.21	0.27
Cost recovery factor	-0.06	-0.22	-0.1	-0.01	0.02	0.24	0.53

7.4.8. Break-even Analysis

Break-even analysis, a common and popular tool for managerial decision-making, has been carried out to find the relation between costs, production volume and profits for different types of fishing units. Since incentive to crew is linked to price and production, the incentive adjusted price was worked out for calculation of break-even point (BEP).

For the large trawlers the unit price and variable cost though higher, their difference - the contribution - is the highest among all categories (Table-7.6). In the case of mini trawlers, the unit contribution is much lower due to the closeness of unit price and variable cost. On the other hand, for traditional NM units and OBM units the relatively lower variable cost resulted in an average unit contribution of Rs.7 per kg of product. In the case of gill-netters, it is the relatively higher price that is responsible for the contribution of Rs.5 per kg of product.

At the prevailing level of costs and price, the level of production is significantly below BEP for all mechanized trawlers and slightly lower for gill-netters. In the case of NM units and OBM units, the level of production is quite higher than the BEP. As a consequence the break-even analysis indicates loss for all trawlers and gill-netters and profit for NM unit and OBM units (Table-7.6).

As a fall-out of break-even analysis, different managerial options to achieve BEP have been worked out (Table-7.6). It could be seen that for attaining BEP, mini trawlers need almost three-fold increase in catch whereas *Sona* trawlers need 84 percent, large trawlers 23 percent, small trawlers 19 percent and gill-netters need only one percent increase. The OBM units and NM units can survive even about 40 percent reduction in catch.

Table - 7.6. The break-even analysis based on average operational results for different classes of fishing units selected for the study

Particulars	Large Trawler	Mini Trawler	*Sona* Trawler	Small Trawler	Gill-netter	OBM Units	NM Units
Total production (tonnes)	91.8	73	104	67.8	29.1	14.2	4.9
Gross revenue (rupees thousand)	8915	2683	1621.2	1106.9	705.6	238.2	73.3
Average unit price (Rs)	97	37	16	16	24	17	15
Incentive-adjusted price (Rs)	89	34	14	14	22	15	8
Fixed cost (rupees thousand)	3054.1	914.4	381.7	241.5	146.9	59.4	19.1
Variable cost per unit (Rs)	62	31	12	11	17	8	1
Unit contribution (Rs)	27	3	2	3	5	7	7
BEP production (tonnes)	113.1	304.8	190.9	80.5	29.4	8.5	2.7
Profit margin (rupees thousand)	-575.5	-695.4	-173.7	-38.1	-1.4	40	15.2
Managerial Options to BEP –Required Changes*:							
In catch	23	318	84	19	1	-40	-44
In price	7	28	12	4	0	-19	-39
In variable cost	-10	-31	-14	-5	0	35	310

**Changes as percentage of the current level*

Since increasing the catch is quite an unrealistic option, the other option is to increase the price (by value addition etc.). Here again the mini trawlers need the highest price escalation of about 28 percent followed by *Sona* trawlers (12 percent) and large trawlers (7 percent). The OBM units and NM units can survive even a reduction in price by respectively 19 and 39 percent.

7.4.9. Sensitivity Analysis

The sensitivity analysis has been carried out to understand the response of overall profitability and performance of different types of fishing units to changes in different variables. As a choice of convenience, the effect of a 10 percent change in price, catch and operational costs (keeping the other factors as it is) on net income, operating profit and net profit were considered (Table-7.7). While the price change generates an equivalent change in the net revenue of all types of units, the change in the operating profit varies from 12 percent in the case of NM units to 123 percent in the case of mini trawlers. Net profit/loss showed tremendous response to price variation, ranging form 29 percent in the case of NM units to an 8 fold change in the case of small trawlers.

A 10 percent change in catch obviously resulted in similar response as the change in price. On the other hand, a 10 percent change in variable cost had different responses on operating profit and net profit, though there was no effect on net revenue (Table-7.7). The response in operating profit varied from 2 percent in the case of NM units to 122 percent in the case of mini trawlers. A higher response has been shown by the net profit/loss varying from 4 percent for NM units to a 6 fold change for small trawlers.

7.4.10. Short-run and Long-run Costs

For a better understanding the short-run and long-run viability of operation of different units, the short-run and long run costs of products and price have been

Table - 7.7. Sensitivity analysis based on average financial results for different classes of fishing units selected for the study

	Large Trawler	Mini Trawler	*Sona* Trawler	Small Trawler	Gill-netter	OBM Units	NM Units
Effect of 10 Percent change in price							
Percentage change in net revenue	10	10	10	10	10	10	10
Percentage change in operating profit	33	123	63	43	41	21	12
Percentage change in net profit	154	35	94	800	522	51	29
Effect of 10 Percent change in catch							
Percentage change in net revenue	10	10	10	10	10	10	10
Percentage change in operating profit	33	122	64	42	41	21	12
Percentage change in net profit	154	35	94	798	521	52	28
Effect of 10 Percent change in variable cost							
Percentage change in net revenue	0	0	0	0	0	0	0
Percentage change in operating profit	23	112	54	33	31	11	2
Percentage change in net profit	107	32	80	621	394	27	4

All figures Absolute percentage change in the current level worked out as detailed in the methodology. The lowest (Re.1) short-run average cost (SRAC) per kg of product landed was obtained for the NM units and highest (Rs.66) for large trawler (Table-7.8). While the SRAC was a nearly equal (about Rs.11) for *Sona* trawler and small trawler, the mini trawlers had a higher SRAC of Rs.31.

The long-run average economic cost (LRAEC) for all the units retained the relative order of SRAC. The LRAEC was highest (Rs.99) for the large trawlers and lowest (Rs.5) for NM units (Table-7.8). The LRAECs of other units were 30 to 50 percent more than their respective SRAC. The long-run average financial costs (LRAFCs) on the other hand, were much closer (only 3-12 percent higher) to the LRAECs in the case of all mechanized units. The LRAFCs were significantly higher than the LRAECs in the case of OBM units (Rs.16.5) and NM units (Rs.17.5).

7.4.11. Labour and Labour Productivity

The capital investment in fishing units has shown variation with the degree of sophistication of fishing technique. There is a replacement of human power with machine power along with mechanisation and motorisation. This is reflected in the various indicators and measures of labour productivity.

The average number of crew employed ranged between four in NM units and 14 in large trawlers (Table-7.9). Since the number of sea days varied over a narrow range, the number of crew employed has been a decisive factor in labour productivity (man-days per unit). Productivity of unit labour on the other hand showed an altogether different trend as the quantity of fish caught and the portion landed varied with vessels. The *Sona* trawlers recorded a production of 62 kg per unit labour followed by small trawlers with an almost similar labour productivity. Mini trawlers (32 kg), large trawlers (28 kg), gill-netters (24 kg), OBM units (16 kg) and NM units (6 kg) were far behind. The gross value added (GVA) per unit labour

Table - 7.8. Short and long run average costs and margin of price over costs for different classes of fishing units selected for the study

Particulars	Large Trawler	Mini Trawler	*Sona* Trawler	Small Trawler	Gill-netter	OBM Units	NM Units
Cost per kg of total catch							
LRAFC	102.15	47.11	16.74	16.51	24.56	16.53	17.54
LRAEC	99.17	43.93	15.52	14.73	22.14	12.2	4.99
SRAC	65.89	31.4	11.85	11.17	17.08	8	1.08
Average price	97	37	15	16	24	17	15
Margin of price over							
LRAFC	-5.2	-10.1	-1.7	-0.5	-0.6	0.5	-2.5
LRAEC	-2.2	-6.9	-0.5	1.3	1.9	4.8	10
SRAC	31.1	5.6	3.2	4.8	6.9	9	13.9

All figures in rupees

was highest for large trawlers (Rs.2767) followed by mini trawlers (Rs.1178), small trawlers (Rs.997), *Sona* trawlers (Rs.960), gill-netters (Rs.570), OBM units (Rs.266) and NM units (Rs.95). However, the net value added (NVA) per unit labour was positive only for gill-netters, OBM units and NM units (Table-7.9).

The production per unit labour was generally higher for mechanized units because of the contribution of other factors of production such as machine power. However, when the number of man-days of labour generated is examined with cost as denominator, a drastically different picture emerges (Table-7.9). For every 1000 rupees capital investment, the NM units produce 16 labour days while the large trawler produces only 0.3 labour days. Similarly for every 1000 rupees of operating costs, the NM units produce 146 man-days of labour compared to 0.6 man-days of labour produced by large trawlers. For every 1000 rupee of total cost, the NM units could produce 32 man-days whereas large trawlers could produce only 0.4 man-days. The average cost of labour was highest (Rs.191) for mini trawlers and lowest (Rs.47) for NM units. Thus labour output per unit of cost was highest for NM units and lowest for large trawlers, other types of units occupying positions in between.

7.4.12. Factors of Sustainability

The environmental and social sustainability of operations of different types of fishing units could be examined by considering some important factors (Table-7.10). The fossil fuel being the most important non-renewable resource, the dependence of mechanised and motorised units on fuel is of great concern to the sustainability of operations. It could be seen that annually an average large trawler consumes about 400 kl fuel while a motorized unit consume about 11 kl fuel. Systems depending on fossil fuel would face severe problems when the global supply-demand gap for fuel increases with consequent rise in price. More over, burning of hydrocarbon fuel contributes to the greenhouse gases and threatens the very sustainability of global environment.

Table - 7.9. Labour output and productivity based on average operational results for different classes of fishing units selected for the study

Particulars	Large Trawler	Mini Trawler	*Sona* Trawler	Small Trawler	Gill-netter	OBM Units	NM Units
Number of crew*	14	11	8	6	7	5	4
Man days per unit	3234	2277	1688	1110	1239	895	772
Catch/ unit labour (kg)	28.4	32.1	61.6	61.1	23.5	15.8	6.3
GVA / unit labour (Rs.)	2756.6	1178.3	960.4	997.2	569.5	266.1	94.9
NVA / unit labour (Rs.)	-158.4	-312.2	-93.4	-9.9	12.9	46.9	16.8
Labour days /Rs1000 of:							
Capital	0.29	0.79	1.69	1.88	2.34	4.58	16.08
Operating cost	0.57	0.99	1.37	1.47	2.49	7.9	145.66
Total cost	0.37	0.71	1.05	1.11	1.93	5.18	31.64
Unit labour cost (Rs)	175	191	160	150	133	48	47

**Shore staff employed not considered*

Table - 7.10. Important factors of sustainability for different classes of fishing units selected for the study

Particulars	Large Trawler	Mini Trawler	*Sona* Trawler	Small Trawler	Gill-netter	OBM Units	NM Units
Fuel consumed (kl per year)	392	106	70	43	41	11	0
Foreign exchange loss (US $) *	74844	29600	18760	11798	5237	1569	0
Foreign exchange gain (US $)	156067	45044	20667	13511	0	680	447
Average catch loss (kg per year)	102097	61000	10462	2038	0	0	0
Export dependency (percentage)	79	76	58	56	0	13	27
Destruction to habitat and other species #	H	H	H	H	N	N	N
Harm to endangered species #	H	H	H	H	M	M	M

** Assuming import of fuel and Rs45 per US $ exchange rate*

 # H: High impact, M: medium impact N: Negligible impact

Dependence on the foreign market is another important factor as locally sustainable systems are less vulnerable to uncertainties brought in by changes elsewhere. Since the trawl fishing is mainly targeted on prawns, which are meant for export, the four types of trawlers are highly dependent on export market. Any variation in price due to changes in global supply will affect the market and price of Indian prawns. The quantum of prawn caught by NM units and OBM units are less compared to the fish, though the revenue earned is significant. However, these units are flexible to adopt other fishing methods, which are not export market oriented. The relative unsustainability of trawl fishing has become obvious in the wake of recent hike in fuel prices and slump in the export markets.

Another important factor is the degree of destruction a method causes to the fishery environment. The trawlers use a non-selective destructive method wherein the bottom of the ground is disturbed much and juveniles of many species are indiscriminately caught and killed. Moreover certain quantity of the catch is discarded which, if brought to shore, could have served as valuable protein food to the malnourished. Trawling and gill-netting (both mechanised and non-mechanised) are reported to cause harm to certain endangered species such as turtles (Vijayakumaran, 2004) and thus pose threat to the biodiversity.

7.5. Conclusions

The result of the analysis of economics of operation, which is the most important part of the present study, has revealed many interesting facts. The upward gradient of CPH of trawlers from south to north (AP to West Bengal) indicated the excessive fishing pressure along AP coast and also the reason for shifting of fishing effort towards Orissa-West Bengal coast. The landing data for 1990-99 revealed an overall stagnation or slight decline in the catch per unit effort of different classes of vessels, except the non-mechanized units. The survey data also showed a general decline in CPH for all units.

While the increase in fishing pressure implied sharing of available resources by more number of units, the increase in cost of inputs (such as fuel) further thinning or even depleting the margin of profit. Consequently mechanised fishing units were forced to modify their exploitation strategies by expansion of area of operation, increase of fishing days and reduction in cruising time. The trawlers significantly increased their fishing time per voyage subject to the limits imposed by different factors. It could be seen that the general shift of trawl fishing towards northeast from Andhra Pradesh observed earlier (FAO, 1993) has become more prominent during recent years. The fact that CPH of trawlers in West Bengal had drastically declined from 1994 onwards could be an indication of intensive fishing off West Bengal waters by vessels from all the three States.

The economic performance of different classes of trawlers has some notable changes when compared to the previous study (FAO, 1993). The *Sona* trawlers which were reasonably well off at the time of the previous study were also facing stress currently while the small trawlers seems to have recovered. The relative positions of large and mini trawlers have remained the same in the current study also. In general all mechanized fishing vessels were earning operating profit only in the short-run and in the long run all were operating on negative profit. Since capital once invested in a fishing unit has zero opportunity cost, most of the vessels would continue to operate so long as the returns covers their SRAC. However, their operations cannot be sustained in the long-run unless they were able to obtain enough revenue to cover their LRAEC.

The non-mechanised and OBM units exhibited better economic performance compared to the other types of fishing units. However, motorisation has a severe

CHAPTER – VIII

SUSTAINABLE RESOURCE EXPLOITATION

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SUSTAINABLE RESOURCE EXPLOITATION

8.1. Introduction

Management of exploited tropical marine fisheries is one of the complex areas of natural resources management due to the inherent characteristics of the resource as well as a multitude of factors affecting the fishery environment. The fisheries manager has to deal with the indirect methods of stock assessment, the multi-species nature of fishery, absence of clear boundaries for the resources, common property nature of resource ownership etc. in the process of deciding the optimum level of exploitation. Therefore marine fisheries management in the tropics poses formidable challenges.

The natural evolution of common property fisheries seems to lead to overexploitation, which in turn has negative consequences on food security, the socio-economic well being of the dependent communities as well as the health of the ecosystem (FAO, 2004). Identifying the key factors responsible for overexploitation and unsustainability of fisheries is a prerequisite for evolving approaches to sustainable resource exploitation. An attempt is made in this Chapter to identify those factors and analyze their interactions to address the long-term concerns of sustainability of marine fisheries along the upper East Coast of India. The approaches and methods in fisheries management being practiced in different parts of the world were discussed to converge on the most suitable and relevant ones for the upper East Coast of India. A conceptual framework for decision-making on optimum fleet size considering different criteria and objectives is also provided. Results of the analysis using a suitable model to decide the optimum combination of fishing effort are presented.

8.2. Optimal Exploitation Model

Analysis of the factors responsible for the overexploitation and unsustainability has been made on the lines of FAO (2002[b] and 2004). The information from published sources has been liberally drawn for the discussions on issues, approaches and methods of fisheries management. The decision framework has been developed based on the available information as well as the conceptual thinking of the author.

The method of analysis developed by Kurup and Devaraj (2000) has been adopted to decide the optimum level of fishing effort for various types of gears and along the three maritime States of the upper East Coast.

In a multi-species multi-gear fishery, the competition for the same resource by many gears of varying characteristics and dimensions does not facilitate a reliable index of abundance of any fish. Though the catch per unit effort (CPUE) of a given type of fishing unit may not reliably indicate stock abundance or the efficiency of that unit, more than anything else, catch, effort and CPUE set the parameters for fishery regulations. So long as effort is the one parameter, which is amenable to physical control, the results accruing from any study should be capable of being translated to details of catch and effort.

The State-wise, gear-wise catch and effort data from NMLRDC for the period 1990-1999 has been used for this analysis. The State-wise gear-wise catch, effort and CPUE for different types of units (trawlers, gill-netters, bag-netters, other mechanised units, motorised crafts operating boat-seines, gill nets, other gears and finally traditional non-mechanised craft) are further split between pelagic and demersal and are separately considered in the first phase. In the second phase the weighted CPUEs for the pelagic and demersal groups have been arrived at separately as indicated below:

$$\text{The weighted CPUE for pelagic } (WCPUE_p) = \frac{\sum_{i=1}^{n} P_i e_i}{\sum_{i=1}^{n} e_i}$$

And

$$\text{The weighted CPUE for demersal } (WCPUE_D) = \frac{\sum_{i=1}^{n} D_i e_i}{\sum_{i=1}^{n} e_i}$$

Where P_i and D_i are the pelagic and demersal catch by the i^{th} gear and e_i is the effort by the i^{th} gear. The standard effort (SF) for pelagic and demersal has been obtained as follows:

$$SF_P = \frac{\sum P_i}{WCPUE_P} x1000$$

$$SF_D = \frac{\sum D_i}{WCPUE_D} x1000$$

The weighted CPUEs and standard effort for the pelagic and demersal groups were calculated for the years 1991 to 1999.

Fitting a response curve (forcing through the origin) of the form $y = a f - b f^2$ to the total catch against the standard effort, the estimate of effort ($f = a/2b$) corresponding to the maximum sustainable yield (MSY) can be obtained from the regression products.

By dividing the MSY by the current CPUE, the expected efforts corresponding to the MSY estimates are obtained. Similarly the MSY efforts (F_{MSY}) in respect of all the States are also arrived at. From the two estimates of F_{MSY}, the weighted averages were obtained for these estimates. The optimum fleet sizes (in number of boats) have been obtained by dividing the weighted F_{MSY} (boat days) by the expected number of fishing days in a year.

8.3. Sustainability of Fisheries

8.3.1. Defining Sustainability

Following the report of the World Commission on Environment and Development (WCED, 1987) and the Earth Summit in 1992, sustainable development has emerged as a new paradigm of development. Sustainable resource exploitation is at the core of sustainable development of any system. The FAO's definition of sustainable development is most relevant to the present study.

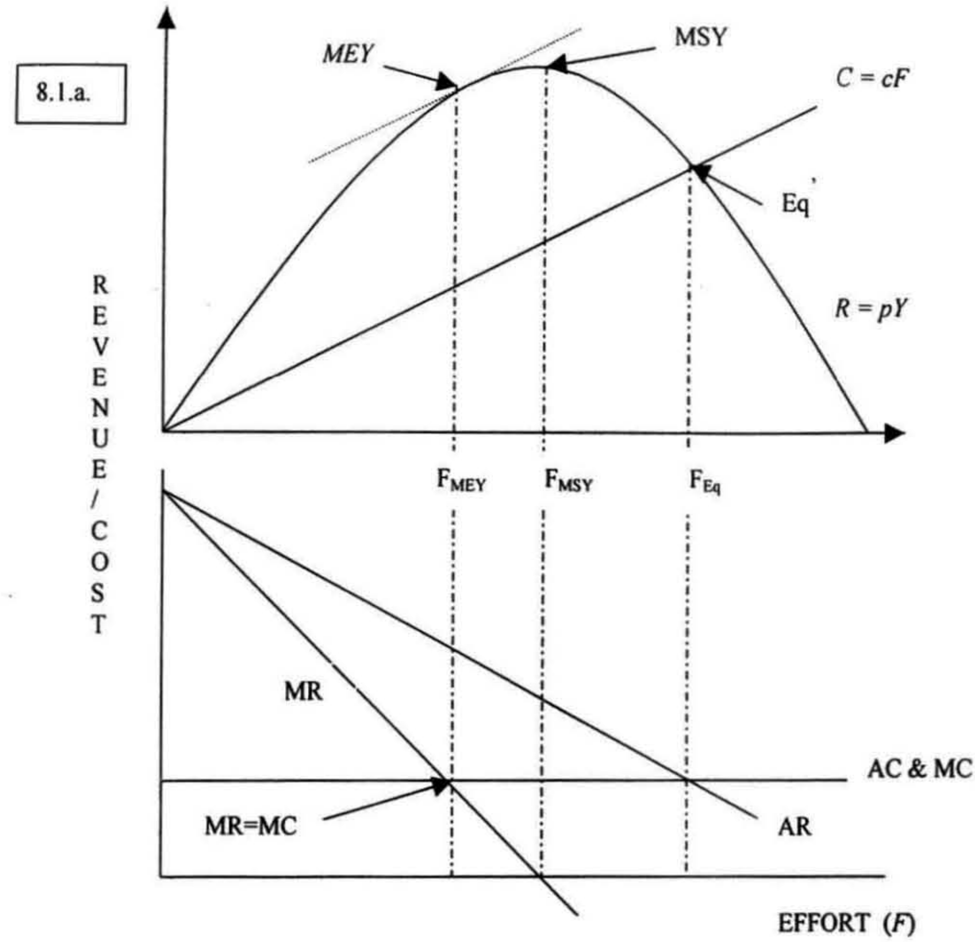
> *"The management and conservation of the natural resource base and the orientation of technological and institutional change in such a manner as to ensure the attainment of continued satisfaction of human needs for present and future generations. Such sustainable development conserves land, water and genetic resources of plants and animals, is environmentally non-degrading, technologically appropriate, economically viable and socially acceptable" (Garcia, 2000).*

Following the definition, sustainability of a fishery could be discussed focussing the four main components namely bio-ecological, social, economical and institutional components. The system moves towards unsustainability when any one of the components is not functioning in the desired manner.

8.3.2. Sustainable Exploitation- Objectives and Issues

Given the natural endowments are undisturbed, the coastal ecosystem can sustain indefinitely. Natural resources such as fish stocks are renewable and are capable of replenishing themselves indefinitely if the exploitation is kept at some optimum level to maintain the 'Bio-ecological Sustainability'. Thus any fishery will be able to yield a certain level of production for any given level of effort namely the 'sustainable yield', theoretically following a bell-shaped curve (Fig.8.1a), without being pushed into dangers of overexploitation. The highest point on the curve is the Maximum Sustainable Yield (MSY).

While the objective of bio-ecological sustainability is to exploit the resources at MSY, the objective of economic sustainability could be to regulate the fishing capacity to maximize the resource rent. The condition for maximizing the resource rent could be explained with the help of Gordon-Schaefer model earlier cited (Chapter-3). The profit maximum in any production system occurs when the marginal revenue equals marginal cost corresponding to the yield point termed maximum economic yield or MEY (Fig.8.1a). For economic sustainability of the system, theoretically the effort should be restricted to ensure the level of exploitation at MEY. The MEY effort is generally lower than the MSY effort and the sustained stock associated with MEY is greater than the stock corresponding to MSY (Bhatta and Bhat, 2001). However, the objective of fisheries management can be other than the economic optimization of the resource exploitation. When fishery resources are not exploited at MSY, the yield difference between MEY and MSY will be irrevocably lost.



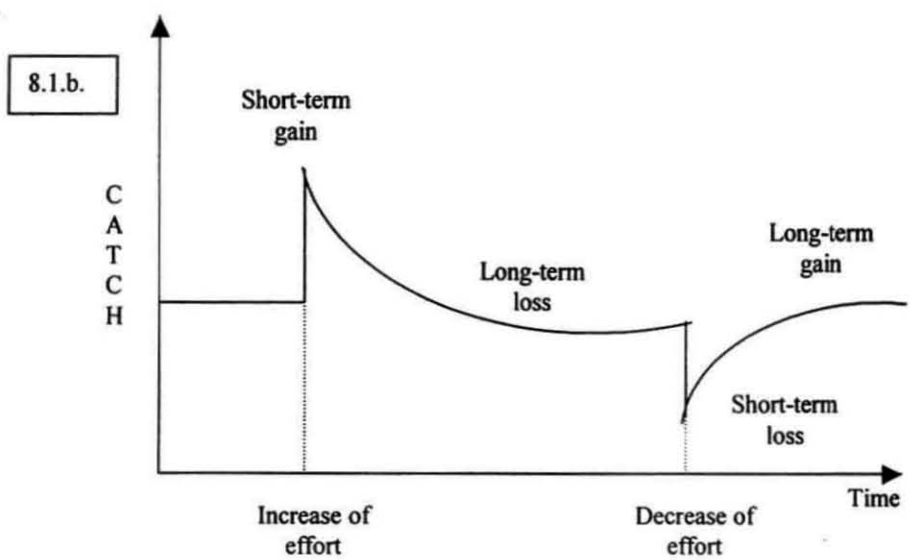


Fig.8.1. a) Gordon-Schaefer bio-economic model and relation between total, marginal and average revenue and cost in an open access fisheries (after Gordon, 1954 and Meany1987)
b) Short-term and long-term effects of changing fishing effort on catch (after Shepherd, 1992)

Social aims of sustainability are to ensure welfare of the dependent communities, optimum utilization of the harvested product (maintaining the nutritive value and avoiding wastage) and to provide safe healthy and fair working environments and conditions. When the optimum exploitation of valuable protein food source becomes social priority, the restriction of effort must be regulated to exploit the resource at MSY.

Social sustainability generally focuses on livelihood issues where welfare objective receives importance. For example, the criteria such as maximum employment generation or assured minimum earnings for a large number of people can also become priority. Thus MSY and MEY may be combined with some other objectives, subject to the basic condition of ensuring reasonable margin of rent to all operating units. Thus a level of yield, which is termed as 'optimum sustainable yield' (OSY), has been coined to represent the ultimate objective.

Institutional objectives of sustainability are the theme of the largest number and most diversified aims of the international instruments. This ranges from use of best scientific information (on resource, environment and ecosystem) and socio-economic studies to use of traditional knowledge.

Two pertinent points to be mentioned in this context are time lag for manifestation of effort control measures and the barrier that exists for the exit from the fishery. The entry of units takes place after a time lag from the investment decision since construction of vessel as per specification and commissioning require certain period of time, which may vary from a few months to more than a year. Theoretically the actual launching of a vessel whose investment decision was made when the fishery was yielding surplus rent could take place when there is no more rent to be shared from the fishery. Similarly, the manifestation of changes in the fishery due to any control or restriction on number of units may also happen after a time lag due to the features inherent to the stock. As Shepherd (1992) has mentioned, increasing the effort will have a short-term gain and a long-term loss while reducing the effort may have a short-term loss and a long-term gain (Fig.8.1b).

Another important feature is the barrier to exit or immobility of the fishery. Such immobility may arise from an inability to liquidate fishing assets without undue loss, indebtedness, isolation, inadequate knowledge of alternative opportunities, habit or inertia, caste restrictions and socio-cultural bonds (Panayotou, 1985). A sort of 'zero opportunity cost' exists for investment in fishing vessels in over capitalized fishery. Accompanied with this, there is a chronic low opportunity cost for the fishermen, arising from low education level and scarcity of alternative employment that perpetuates their poverty. The management strategies, approaches and plans must take care of these two points.

8.3.3. Factors of Unsustainability and Overcapitalization.

Given the common property nature, in the absence of some explicit institutional arrangements, fisheries will naturally become unsustainable with respect to at least one of the components mentioned above. It is quite possible that fisheries will become economically unsustainable before ecological unsustainbilty becomes possible. There are six major factors leading to unsustainability (FAO, 2002[b]) that needs further elaboration within the context of the marine fisheries of the upper East Coast.

Inappropriate Incentives: Marine fisheries in India, like in several other important fisheries of the world, operate in response to incentives that promote unsustainable practices rather than sustainable ones. The classic example is the fuel subsidy given to fishing vessels. The inappropriate incentives coupled with market distortion lead to short-term view and overcapitalization.

High Demand for Limited Resources: Demand for fish is ever increasing in the country while supply is not increasing substantially to satisfy the demand. The high value and high demand for shrimp in the export market is the reason for unbridled expansion of the trawl fishery in the country. The trawl fishing, which is the most dominant fishing method in the country, is also the most unsustainable one compared to other methods.

Poverty and Lack of Alternatives: Conditions of poverty and lack of alternative is an important factor for the expansion of traditional fisheries sector.

Complexity and Inadequate Knowledge: The complexity of the fishery system and inadequate knowledge of the fishery environment is one of the important factors contributing to the unsustainability of fisheries. While the utility of the existing knowledge is not tested by incorporating them in the decision-making process, there is very little incentive for further advancing the knowledge.

Lack of Governance: Lack of appropriate and effective governance is the most important of the six factors of unsutainability. The absence of suitable policies, institutions and regulatory mechanisms, and the inability to implement necessary measures is the characteristics of the marine fisheries in India. There is an overall lack of transparency and participation in the management system undermining the confidence of stakeholders and their willingness to support management measures.

Inter-sectoral Interaction: Interaction of fisheries sector with other sectors and the environment is an area of great concern to sustainability. The issues of conservation of endangered species such as turtles and preserving biodiversity have been in focus in recent years. The development of coastal aquaculture is threatening the critical habitats of many important species. The impact of coastal pollution and the effects of many anthropogenic activities is becoming a major threat to sustaining fisheries.

8.3.4. Paths to Sustainability

Having discussed the factors affecting the sustainability of fisheries, it will be appropriate to explore the course to be chosen to find solutions. FAO (2004) suggested the following paths to seek solutions to the issues of unsustainability:

- Rights: The Granting of secure rights to resource users (individually or collectively) for use of a portion of the catch, space or relevant aspect of the fishery.
- Transparent participatory management: The granting of meaningful role to stakeholders in the full range of management (e.g. Planning, science, legislation and implementation).
- Support to science, planning and enforcement: Providing the necessary resources for all aspects of management of the fishery.
- Benefit distribution: Using economic tools to distribute the benefits form the fishery to address community and economic sustainability
- Integrated policy: Planning fisheries including setting explicit objectives that address all the dimensions of sustainability and interactions among the factors of unsustainability.
- Precautionary approach: Application according to FAO guidance.
- Capacity building and raising public awareness: Development and application of programmes to better inform policy makers and the public at large about main fisheries issues.
- Market incentives: Using market tools in situations where they are appropriate for addressing factors of unsustainability.

Bestowing user right to communities such as co-operatives as is practiced in Japan (Yamamoto, 1995) is an alternative, which can be explored once the cooperative systems become well developed. Drawing examples from the Asia-Pacific region Kurien (2003) has highlighted how small-scale, community-based fishing is both ecologically and economically suited to make a blessing of the coastal commons that will simultaneously ensure sustainable natural resource use and community well-being. This could be an ideal method for protected area management, especially in Orissa where communities can ensure sustainable exploitation and conservation of resources. Following the other paths could bring about the desired shift toward sustainability in the fishery of the upper East Coast.

8.4. Fisheries Management

8.4.1. Fisheries Management Defined

The meaning of fisheries management has spatial and temporal variations due to the difference in scope and objectives. Gulland (1974) stated that fishery management may be considered as any control for adjustment of fishing operations (the fishing effort, gear, size of the fish etc.) to optimize the use of natural resources. Panayotou (1982) defines fisheries management as the pursuit of certain objectives through direct or indirect control of fishing effort or some of its components. According to Clark (1985), fisheries management involves biologically oriented regulations such as catch quotas, mesh restrictions, seasonal closures, quota systems and the like as well as possible economic instruments such as royalties, taxes and subsidies.

8.4.2. Management Objectives and Strategies

Within the frame of ecological sustainability, the broad objectives of fisheries management may include conservation of fisheries resources and their environment, maximization of economic returns from the fishery, and payment of fees to the community from profits made by the exploitation of a public resource. The relationship between stock assessment, management objectives, strategies and regulations can be better understood with the help of a diagram (Fig. 8.2). Generally the management plan should contain a description of:

- The present state of development and exploitation of the fishery
- Policy aims or objective of managing the fishery
- Management strategies which would achieve the objectives
- The regulations, which may be applied to the fishery under various strategies.

8.4.3. Approaches and Methods

Technological interventions and policy or management interventions are the two broad approaches of fisheries management. In the common property context, Meany (1987) detailed three basic forms of management of marine fisheries namely taxation, output controls and input controls. These methods are discussed below to decide their applicability along the UEC of India.

Taxation: The taxation approach involves controlling the level of fishing capacity and fishing effort by imposing a tax (such as a levy on each kg of fish landed) on operators in the fishery, which may at the most equal the maximum resource rent the fishery can generate. This would in effect increase the fishing costs to the point where total cost (actual cost plus tax) curve cutting the total revenue curve at MEY. There is no incentive for entry of additional boats because of the negative resource rent implied. The absence of proper monitoring and accounting mechanism, large number of landing places, diverse marketing channels multitude of crafts and gear

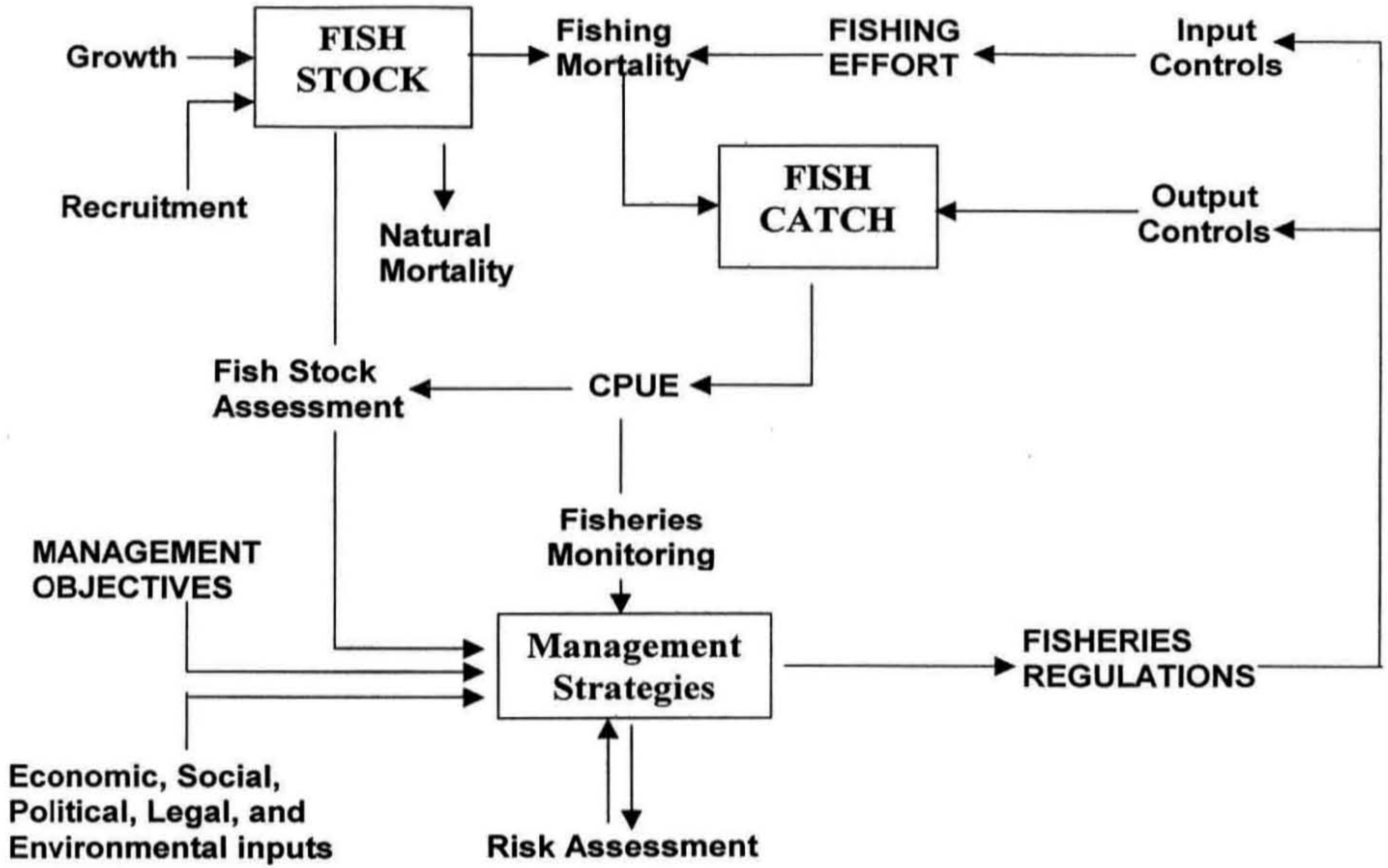


Figure. 8.2. Relationship between Fish stock assessment, management objectives, strategies and regulations (adapted from King, 1995)

as well as species, variability in the species abundance and price etc. existing in the country are not favourable for implementing the taxation.

Output control: Fixing the total allowable catch (TAC) and issuing individually transferable quota (ITQ) are popular methods of output control in fishery. The total of all quotas is equal to the TAC, which in turn may be based on MSY or MEY. This method is successfully being applied in Europe and is quite effective in fleet rationalization in an over-capitalized fishery. The ITQs are saleable or transferable and ensure a well-defined bundle of rights including a predetermined proportion of the catch. Implementing the ITQ is also quite difficult in India because of the reasons cited in the above section and also the ill-defined boundaries.

Input control: Input controls involve limiting of number of boats and gears to indirectly control exploitation of resources in wider range of circumstances. Limited entry itself does not directly attack the problem of dissipation of economic rent and unlike ITQ it fails to provide an autonomous adjustment mechanism. However, it is gaining recognition among fishermen as a method to ensure sustainable exploitation of resource.

Technological interventions in input control are specific to situations and species being harvested or targeted. The common technological intervention is *mesh size control*. Restriction on the mesh sizes of the net ensures exclusion of certain size of fish to be caught. This is to allow the targeted fish species to grow to an optimum size before being caught in the net. However, in a multi-species fishery as in the tropics, where there are many species being targeted, this method would be difficult to apply because the adult specimen of some species may be smaller than the young ones of another species.

Spatial and Temporal Closures: Apart form restricting inputs and outputs, specific spatial and temporal closures are commonly practiced management methods. Restrictions of fishing during a particular season or a given area are mainly meant to ensure protection of breeding and nursery of important species. Area restriction is also imposed for protection of nursery grounds and biodiversity conservation. In many places marine protected areas (MPAs), natural parks and sanctuaries are demarcated for conservation. While fishing has been prohibited in the Gahirmatha and Bhitrakanika Wildlife Sanctuary area in Orissa, seasonal (April- May) restriction of trawling is being practiced along the upper East Coast.

The area and seasonal restrictions are beneficial to address certain biological issues but are incapable of solving the problem of economic overfishing and overcapitalization. In the Indian context, reducing fishing effort in a phased manner to the required level only can sustain an economically viable fleet. The control of effort again can be based on different criteria discussed earlier. The following section details the results of the analysis aimed at deciding the optimum fleet size along the upper East Coast of India.

8.5. Optimum Combination of Fleet

The convention of the fisheries mangers all over the world is to estimate the maximum sustainable yield (MSY) and then work out the optimum combination of fleet needed to exploit the resources. Though there are reliable and robust models available for estimating the MSY in single species fisheries of the temperate waters, such models are not applicable for tropical multi-species multi-gear fisheries. To overcome this problem Kurup and Devaraj, 2000 have developed an alternate method with quite reliable results.

As mentioned elsewhere in the methodology, the gear-wise, species-wise catch data of the three states of the upper East Coast for 1990-99 was considered for analysis. The weighted catch per unit effort (CPUE) and standard effort calculated for pelagic and demersal groups are presented in Table-8.1. The response curve fitted with total catch against standard effort yielded the following results:

Particulars	**Demersal**	**Pelagic**
Average annual effort	558824	1263479
Average annual catch	122477	161491
Coefficient *a*	0.4319589	0.2073363
Coefficient *b*	3.73E-07	6.05E-08
MSY-effort (boat days)	578891	1713769
MSY-Catch (tonnes)	125028	177663

The average landings of demersal and pelagic resources in different types of gears during 1990-99 are given in Table-8.2. The estimated maximum sustainable yield of demersal and pelagic resources along the upper East Coast based on the data for the period 1990-99 is given in Table-8.3. The average catches per unit effort of demersal and pelagic resources in different types of gears during 1990-99 are given in Table-8.4. The estimated MSY efforts of demersal and pelagic resources in different types of gears are given in Table-8.5.

The estimated weighted efforts, the average numbers of days of operation and estimated optimum fleet for different types of gears for the different States are given in Table-8.6. It could be seen that only 1011 trawlers, 867 gill-netters, 179 Bag-netters, 752 other mechanized units, 1242 outboard-motored units and 9706 non-mechanized units are sufficient to exploit the fishery of the upper East Coast. The current strength of all categories of crafts is alarmingly high (as mentioned in

Table - 8.1. The weighted catch per unit effort (CPUE) and standard effort calculated for pelagic and demersal groups during 1990-99.

	Total Catch		Weighted CPUE		Standard Effort	
Year	*Pelagic*	*Demersal*	*Pelagic*	*Demersal*	*Pelagic*	*Demersal*
1990	121699	111085	113	173	1076982	642110
1991	133054	99889	97	166	1371691	601741
1992	163193	113097	202	174	807886	649983
1993	178930	143258	204	200	877108	716290
1994	123772	111575	94	210	1316723	531310
1995	143080	121656	107	236	1337196	515492
1996	168965	122798	127	262	1330433	468695
1997	191961	122004	156	250	1230519	488016
1998	192039	130486	143	283	1342930	461081
1999	198219	148921	102	290	1943324	513521

Table - 8.2. The average landings of demersal and pelagic resources in different types of gears during 1990-99.

	MTN	MGN	MBN	MOTH	OBBS	OBGN	OBOTH	NM	Total
Demersal									
AP	40149	5499	6	428	70	4423	846	14422	65843
OR	19449	5556	0	892	0	1473	1040	2822	31232
WB	7717	8025	4743	1377	1	75	491	2976	25405
UEC	67315	19079	4749	2697	71	5971	2377	20220	122479
Pelagic									
AP	19384	7908	0	420	1216	8947	2386	55047	95308
OR	6029	4750	0	58	0	2578	183	6353	19951
WB	3338	23394	13160	229	2	460	424	5225	46232
UEC	28751	36052	13160	707	1219	11985	2993	66625	161492

Table - 8.3. The estimated maximum sustainable yield of demersal and pelagic resources along the upper East Coast based on data for the period 1990-99.

	MTN	MGN	MBN	MOTH	OBBS	OBGN	OBOTH	NM	Total
Demersal									
AP	40985	5614	6	437	71	4515	864	14722	67214
OR	19854	5672	0	911	0	1504	1062	2881	31884
WB	7878	8192	4842	1406	1	77	501	3038	25935
UEC	68717	19476	4848	2753	72	6095	2427	20641	125029
Pelagic									
AP	21325	8700	0	462	1338	9843	2625	60560	104853
OR	6633	5226	0	64	0	2836	201	6989	21949
WB	3672	25737	14478	252	2	506	466	5748	50861
UEC	31630	39662	14478	778	1341	13185	3293	73297	177664

Table - 8.4. The average catches per unit effort of demersal and pelagic resources in different types of gears during 1990-99.

		MTN	MGN	MBN	MOTH	OBBS	OBGN	OBOTH	NM
Demersal									
	AP	368	42	6	177	27	23	59	10
	OR	327	53	0	112	0	37	100	8
	WB	567	152	163	162	14	2	14	47
	UEC	362	64	163	133	27	40	94	11
Pelagic									
	AP	179	56	0	60	210	42	456	43
	OR	125	44	0	4	0	24	16	20
	WB	301	439	490	28	26	13	12	80
	UEC	158	117	489	36	210	44	128	40

Table - 8.5. The estimated MSY efforts of demersal and pelagic resources in different types of gears.

	MTN	MGN	MBN	MOTH	OBBS	OBGN	OBOTH	NM
Demersal								
AP	111372	133667	1000	2469	2630	196304	14644	1472200
OR	60716	107019		8134		40649	10620	360125
WB	13894	53895	29706	8679	71	38500	35786	64638
UEC	189826	304313	29742	20699	2667	152375	25819	1876455
Pelagic								
AP	119134	155357		7700	6371	234357	5757	1408372
OR	53064	118773		16000		118167	12563	349450
WB	12199	58626	29547	9000	77	38923	38833	71850
UEC	200190	338991	29607	21611	6386	299659	25727	1832425

Table - 8.6. The estimated weighted efforts the average number of days of operation and estimated optimum fleet for different types of gears.

	MTN	MGN	MBN	MOTH	OBBS	OBGN	OBOTH	NM	Total
Effort (boat days)									
AP	113912	146061	0	3793	5945	220892	6775	142041 5	1917793
OR	58600	112351	0	8405	0	71148	10888	352500	613892
WB	13306	57409	29587	8726	75	38867	37192	69181	254343
UEC	192975	326729	29641	20893	5962	229524	25766	184192 2	2673412
No of days	180	156	150	150	189	200	200	200	
Estimated Optimum fleet									
AP	633	936	0	25	31	1104	34	7102	9865
OR	326	720	0	56	0	356	54	1763	3275
WB	74	368	197	58	0	194	186	346	1423
UEC	1072	2094	198	139	32	1148	129	9210	14022

Chapter-5) so that drastic reduction of effort is necessary for sustainable exploitation of resources. An earlier exercise on the bio-economics of the demersal fisheries of the UEC (FAO, 1993) has recommended about 40 percent reduction in the 1991 trawl fishing effort to sustain the demersal fisheries.

A comparison of the present results with that of an earlier work (Kurup and Devaraj, 2000) will give an indication of the changes that have taken place during recent years (Table-8.7). The present estimate shows significant increase in gill-netters and marginal increase in trawlers and bag-netters. The relatively good performance of gill-netters, the changed fishing strategies of trawlers and expansion of bag-net fishery in West Bengal are in agreement with this change. There is indication of expansion of outboard gill-netters due to their comparatively good performance while the reverse is true for other mechanized and motorized units. If all the units except bag-netters are assumed to have 200 days of operation (actually trawlers are currently operating more than 200 days), then there is a need to reduce 142 trawler units and 515 gill-netters and 34 other mechanized units from the optimum fleet estimated earlier (Table-8.7).

8.6. Framework For Optimum Exploitation

Effective decision-making in fisheries requires the provision of 'fisheries management advice based on applying general principles of problem-solving including quantitative evaluation of alternatives (versus strictly biological advice or economic advice, etc.) and projection of their strategic implications on all aspects of the fishery system' (Lane and Stephenson, 1995). A suitable framework for ensuring optimum exploitation strategies must address the above aspect properly (Fig.8.3).

Table - 8.7. Comparison of fleet size with previous study and enhanced days of operation for different types of gears.

	MTN	MGN	MBN	MOTH	OBBS	OBGN	OBOTH	NM	Total
Estimated fleet (by Kurup and Devaraj, 2000) based on 1986-1996 data									
AP	541	502	0	17	4	593	165	7876	9698
OR	391	355	0	663	0	33	104	1470	3016
WB	79	10	179	72	0	347	0	360	1047
UEC	**1011**	**867**	**179**	**752**	**4**	**973**	**269**	**9706**	**13761**
Estimated Optimum fleet (Current study) based on 1990-1999 data									
AP	633	936	0	25	31	1104	34	7102	9865
OR	326	720	0	56	0	356	54	1763	3275
WB	74	368	197	58	0	194	186	346	1423
UEC	**1072**	**2094**	**198**	**139**	**32**	**1148**	**129**	**9210**	**14022**
Change	*61*	*1227*	*19*	*-613*	*28*	*175*	*-140*	*-496*	
Estimated Optimum fleet assuming 200 days operation for all gears except MBN									
UEC	930	1579	198	105	32	1148	129	9210	13980
Change	*-142*	*-515*	*0*	*-34*	*0*	*0*	*0*	*0*	

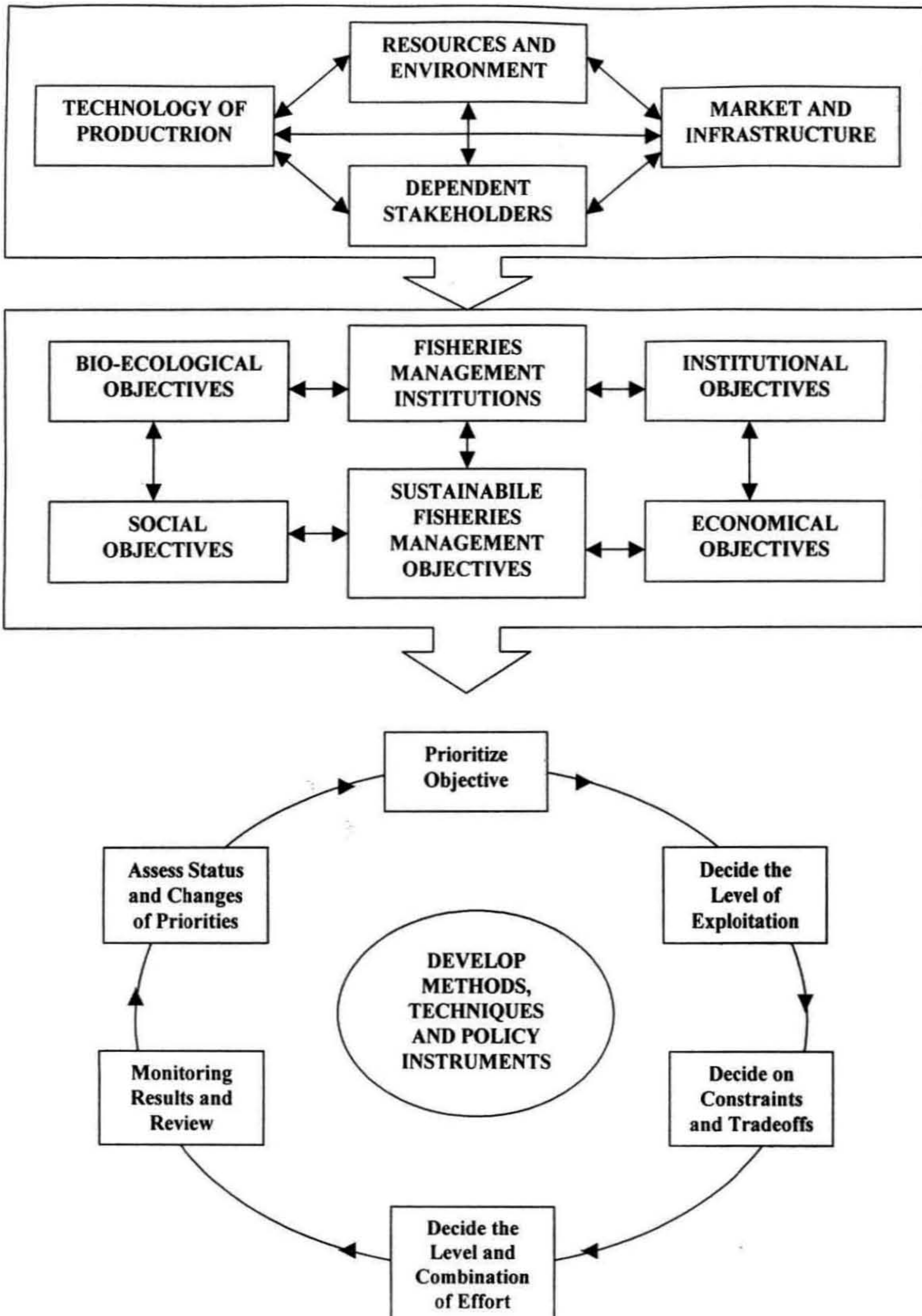


Fig. 8.3. A framework for evolving optimum exploitation strategies for sustainable management of fisheries

The prerequisite for evolving optimum exploitation strategies is the availability of information on various components of the fishery environment and their inter-relations. The ecological and biological charectisitics of resources, the technology of production and processing, the markets and infrastructure available as well as the socio-economic aspects of the dependent communities are to be properly understood to develop the necessary institutional mechanism for management of resources. Since the system is dynamic, the status and interrelations among components will change over time. Therefore updating of the relevant information is of great importance for which permanent research establishments are necessary.

Once the basic knowledge is acquired an institutional set up to manage the resource can be established. This establishment would set the sustainable fisheries management objectives with due regard for the bio-ecological, social, economic and institutional components of sustainability. The operational goals are prepared based on the broad objectives and they are prioritized according to the importance at the context. Once the priorities are identified, the level of exploitation of the resource and the level of effort has to be decided and the constraints and tradeoffs to be made to achieve that level are to be identified. The next step is to work out the optimum combination of effort needed to achieve the set goals. There is tremendous scope for developing and improving various methods and techniques available for deciding the optimum level of exploitation, effort, combination of effort etc.

The institutional mechanism should be strengthened and funded for implementing the protocol of measures. The review of the performance and evaluation of the results are very important to change proprieties of objectives and to improve upon the methods and techniques. The entire process should follow the dynamic cycle of change to make to system move towards sustainability in the long run. The concluding Chapter will examine briefly the current fisheries regulatory framework.

8.7. Conclusions

The various factors have contributed to the unsustainability and overcapitalization of the marine fisheries of the upper East Coast of India. The most important ones are improper incentives, lack of governance, lack of alternatives, high demand for limited resources and limited knowledge of the complex system. The need for adopting suitable paths to sustainability is strongly felt.

Since open access in marine fisheries lead to unregulated entry of fishing units and ultimately overcapitalisation, fisheries management initiatives primarily are directed to control of fishing effort. While the tradeoff between short-term loss and long term gains is difficult to make, the immobility of the fishery adds another difficult dimension. Of the various approaches to management, output controls methods are quite out of place along the upper East Coast because of a large number of landing places as well as a variety of species and gears. The input control measures like restricting the number of craft and gears along with some spatial and temporal restrictions seem to be most suitable for the upper East Coast.

The current average level of production from the upper East Coast is a little below the estimated MSY for both pelagic and demersal groups. However the existing fishing fleet is far greater than the required number. The optimum combination of fishing fleet worked out in this study indicates the need for drastic reduction in the fleet. Since this involves various socio-economic implications, the modality of controlling the effort has to be worked out within a broad framework.

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CHAPTER – IX

SUMMARY AND CONCLUSIONS

CHAPTER – IX

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9.1. A Brief Overview

Fisheries management essentially involves ecologically (or biologically) sustainable exploitation of resources ensuring maximum welfare to the dependent communities employing the best combination of technologies. The policies, interventions and institutional mechanisms are very important components in the fisheries management system. Studies on different aspects of fisheries aim to analyse the underlying features of the fishery environment and to suggest suitable technical or policy interventions for resolving the issues of fisheries management.

As a logical conclusion of the present study it is necessary to summarise the important outcomes, draw inferences from the findings, recommend suitable policy measures and suggest future course of research. This Chapter aims to provide a Chapter-wise summary of the findings of the study and draw conclusions in the background of the various objectives. Examining the challenges and opportunities, this Chapter indicates some policy measures and options for sustainable exploitation of marine fisheries along the upper East Coast of India. At the end some suggestions are given for future research after citing the limitations of the present work.

9.1.1. Background

The need for sustaining fish production to provide protein food for the growing world population is highlighted in the introduction followed by a brief review of global fish production and fish production in India, before stressing the need for an integrated study. In the subsequent Chapter, a background is provided by reviewing the literature on exploratory surveys, resource status reviews, stock assessment and management, technology, economics, marketing, and interdisciplinary studies. The objectives, scope, data sources and methodology figure in the second Chapter. The salient findings of the subsequent Chapters are the summarised below.

9.1.2. Biology and Bio-economics

Biological characteristics and features of different exploited species have a strong bearing on their fishery. The changes in production could be generally related in one way or other to the perturbations in natural environment or factors pertaining to exploitation. The various natural factors and environmental perturbations controlling the spatial and temporal distribution of different species are uncontrollable and contribute to the uncertainty of the fishery environment. The important characteristics of the marine fisheries, which have strong implication on the policy and research, are the open access and multi-species multi-gear nature.

The marine fishery exhibits the features of a typical common property resource (CPR). While the unbridled expansion of fishing effort is a threat to the sustainability of the system, the dynamics of CPR tend to result in an overexploited and overcapitalised state.

Bioeconomic models identify two levels of exploitation namely the MSY and MEY, the former is the biological optimum and the latter connotes the level at which revenue is maximum for a given technology. The choice has to be made based on the criteria and objectives of management.

As in other tropical seas, the fishery along the UEC is of multi-species nature. Further, any given species may be exploited by a number of gears with varying catching efficiency. This implies that single species stock assessment models widely used in world fisheries are quite unsuitable for application in the fishery of the upper East Coast. While development models to suit the dynamics of multi-species, multi-gear fisheries is a laborious task, the generation of data needed to fit such models is practically impossible due to various constraints. Therefore, only macro level models of stock assessment are useful for application in the context of UEC.

9.1.3. Resource Potential and Exploitation

Though a general increasing trend in the annual total landings of the UEC during 1990-1999 was apparent, the statistical analysis revealed that there is no significant difference in the total landing between different years. Similar was the case of landings by pelagic, demersal and mechanised sectors. This implies that the additional fishing effort in recent years has no significant effect on the catch. The production of prawns is indicated to be responsive to spatial and temporal changes in the fishing pressure. The changing strategies of trawlers to maximise the prawn catch could be the reason for this positive response.

The estimates of the fishery resources of the EEZ and seas adjoining the upper East Coast at different points of time generally indicated further scope for increasing the yield. The resources within the inshore areas up to 50-m depth are being fully exploited. The various factors of technology and market may permit the existing classes of vessels to venture into areas up to 70 m depth but not deeper. Accordingly, about 0.46 million t of fish can be harvested under the best of technology, market and environmental conditions. The estimate of 0.48 million t exploitable potential derived from maximum contribution approach (MCA) was closer to the above figure. On the other hand, the estimates obtained from relative response model (0.39 million t) and Working Group method (0.3 million t) were much lower. Considering the current annual average production of 0.29 million t, the estimate of MCA can be taken as an upper (optimistic) limit while that of relative response model can be taken as lower (pessimistic) limit.

9.1.4. Fishing Technology and Operational Capabilities

A wide variety of fishing craft and gear are being deployed in the exploitation of marine fishery resources of the upper East Coast. Since traditional units use different craft-gear combinations at different times and localities, they are more flexible to adapt to the changing environment and make the best use of the resources. With gear-specific designs, mechanised units are less adaptive and vulnerable to the changes in resource environment. The energy intensive mode of fishing is another factor posing threat to the sustainability of operation of mechanised fishing units, especially the trawlers.

Over the years both the traditional and mechanised sector have undergone significant changes. There has been an increase in number of units operated along with a general trend towards mechanisation and motorisation. Compared to the West Coast, a slower rate of displacement of traditional technologies as well as a greater decrease in traditional gears has been observed along the upper East Coast. On the other hand, increase in mechanised gears was more along the upper East Coast. The number of mechanised boats per unit length of coastline was more in West Bengal while that of traditional crafts and gillnets were more along Andhra Pradesh coast.

The analysis of capacity utilisation and VIU indicated that mechanised trawlers, bag netters and non-mechanised units and are being utilised at or near optimum level. Certain spatial and temporal limiting factors were identified for the operation of different units. While traditional units are forced to adopt daily voyages, the mechanised units have capabilities for multi-day operations. The capacity of the winch will restrict fishing operation of small and *Sona* trawlers to 50 and 70 m depth respectively. Water storage capacity will restrict the number of days at sea of small and *sona* trawlers to 10 and 12 days respectively. Fish catching rate will be posing limitation on the number of days at sea for mini trawlers and large trawlers

9.1.5. Marketing and Price of Fish

Several factors like diversity of species in the catch, uncertainty in supply, perishable nature of the product, inadequate infrastructure and large number of intermediaries in the channel affect the price of marine fish.

The ex-vessel price of fish at Visakhapatnam has shown an increasing trend over the years. The average unit value realised in the export market followed a similar trend of the US $ exchange rate. With the change in the composition of the export basket, the AUVR varied over the years significantly. The major determinant was the percentage of shrimp in the quantity exported. The prices of exported varieties were influenced by the prices in the export markets. More than 60 percent of the growth in AUVR has been due to the devaluation of rupee against the US $. The fuel prices followed a trend similar to the exchange rate of US $. However, the rate of increase in fuel price was much higher than the rate of increase in AUVR. Lack of control over the price of output (especially in the export market) and also major inputs (HSD) render the industrial fishing most vulnerable and unsustainable.

9.1.6. Economics of Operation

Analysis of general trend of catch and effort showed an overall saturation of effort as indicated by the general reduction in CPH for mechanised trawlers and gill-netters. A slight improvement in CPH was indicated for traditional non-mechanised units. The trends of CPUE and CPH of all units in West Bengal showed wide fluctuations as compared to that in Orissa and Andhra Pradesh.

Seven types of fishing units were considered for detailed analysis of economic performance. Some key factors such as distance to the ground, crew strength, and duration of fishing have influenced the fishing operations. In general the mechanised fishing units along the upper East Coast of India have resorted to voyage fishing according to the changed scenarios. Traditional units by and large were unable to change their operational duration.

Capital investment in fishing units varied between Rs.11 million for large trawlers to less than Rs.50 thousand for non-mechanised units. The important heads of capital investment for mechanised units were the hull and engine while hull and gear were the major heads for non-mechanised units. The annual fixed costs varied from less than Rs.20 thousand for NM units to over Rs.3 million for large trawlers. The annual operational costs ranged between Rs.5300 for NM units and Rs.5.7 million for large trawlers. The total annual revenue varied between Rs.73 thousand for NM units and Rs.8.9 million for large trawlers. The operating profit was positive for all units selected and varied between Rs.32 thousand for NM units and Rs.2.5 million for large trawlers. However all trawlers recorded net negative profit and the surplus over operating cost and 12 percent ROI was negative only for mini trawlers.

The fuel cost to account for 46 to 64 percent of the harvesting cost per sea day for mechanised and motorised units whereas gear replacement accounted for 68 percent of the daily harvesting cost for NM units. The harvesting cost per sea day varied from Rs.28 for NM units to Rs.28,000 for large trawlers.

Financial ratios involving operating profit was positive for all units and those involving net profit was negative for all trawlers, indicating a relatively unhealthy state of industrial fishing long the UEC. The break-even analysis showed that mini trawlers needed almost three-fold increase in catch whereas *Sona* trawlers needed 84 percent, large trawlers 23 percent, small trawlers 19 percent and gill netters one percent increase in catch for breaking even. OBM units and NM units can withstand about 40 percent reduction of catch before breaking even. Sensitivity analysis revealed that a 10 percent change in price or catch resulted in equivalent change in net revenue. The operating profit and net profit changed respectively by about 29 percent and 12 percent in the case of NM units and 123 percent and nearly eight-fold in the case of mini trawlers. A 10 percent change in variable cost caused a two percent change in the operating profit of NM units to 122 percent change in the case of mini trawlers.

The short-run average cost per kg of fish for NM units was about one rupee whereas the same for large trawlers worked out to be Rs.66. The long-run average economic cost varied between Rs.5 for NM units and Rs.99 for the large trawlers. The average prices of fish have to be equal to or exceed the SRAC and LRAEC for making the operations viable in the short and long run respectively.

Average number of crew employed in fishing units varied between 4 and 14 and the analysis of labour productivity revealed that productivity per unit labour was 62 kg in the case of *Sona* trawlers and 6 kg for NM units. However the net value added was positive only for gill-netters, OBM units and NM Units. The cost of labour varied form Rs.47 per man-day in NM units and Rs.191 per man-day in the case of mini trawlers. The number of man-days of labour generated for every unit investment, operating cost and total cost was highest in NM units and lowest in large trawlers. Analysis of the factors of sustainability indicated that trawl fishing is most unsustainable due to the dependency on fossil fuel, destructive mode of fishing, discard of fish and other environmental interactions.

9.1.7. Sustainable Exploitation

Sustainable resource exploitation is an integral agenda of sustainable development, which essentially aims to ensure inter-generational and intra-generational equity. In a country like India, MSY is the most desirable and acceptable level of exploitation of fishery resources than MEY. Though at MEY, the operation is economically most efficient, there is still some more fish that can be caught. Since providing cheap and much needed protein food to the people is a priority for India, full exploitation of the resource at MSY must be preferred.

Since open access in marine fisheries lead to unregulated entry of fishing units and ultimately overcapitalisation, fisheries management initiatives primarily are directed to control of fishing effort. Several factors such as improper incentives, lack of governance, lack of alternatives, high demand for limited resources and limited knowledge of the complex system have led to unsustainability and overcapitalisation in the marine fisheries of the UEC.

Of the various approaches to management, output control methods are quite out of place along the upper East Coast because of a large number of landing places as well as a variety of species and gears. The input control measures like restricting the number of craft and gears along with some spatial and temporal restrictions seem to be most suitable for the upper East Coast.

The current average level of production from the upper East Coast is a little below the estimated MSY for both pelagic and demersal groups. However the existing fishing fleet is far greater than the required number. The optimum combination of fishing fleet worked out in this study indicates the need for drastic reduction in the fleet. At this point, apart from the biological and economic aspects, the social aims of sustainability such as welfare of the dependent communities and providing livelihood and employment etc. has to be considered. This needs evolution of appropriate strategies and methods in within a broad framework by an iterative process with participation of the stakeholders.

9.2. Conclusions

9.2.1. Findings

The present study has achieved the broad objectives of analysing the biological, technological and economic aspects of the harvesting sector of the marine fisheries along the upper East Coast of India from the perspective of sustainable resource management. In that pursuit the study has:

- Examined the biological and bio-economic features of exploited of fishery resources and discussed different aspects of fish population dynamics and stock assessment.

- Reviewed the estimated potential resources and discussed the exploitable potential in the light of present trends in exploitation along the upper East Coast of India as well as estimates made using three different methods.

- Took stock of the technological aspects of important fishing methods, craft gear and their temporal changes in numbers along the upper East Coast of India and assessed the operational capabilities and limitations of different fishing units.

- Analysed the important pricing factors of fish, the price trends in local and export markets, and their relationship with exchange rate of US $ and price of fuel, from the point of sustainability.

- Analysed the pattern of investment, profitability, long and short-run operational features, sensitivity, labour productivity and factors of sustainability of seven different types of fishing units selected for the study.

- Discussed the factors of unsustainability, paths to sustainability and reviewed various approaches and methods of management to converge on methods suitable for sustainability of fishing operations along the upper East Coast of India.

- Estimated the biologically sustainable yield from the fishery of the upper East Coast of India, arrived at the optimum number of different class of vessels that can be sustained by the fishery and discussed a framework for operationalising the objectives of management.

9.2.2. Evaluation of Proposed Hypothesis

Th outcome of the present study is sufficient for evaluating the general hypothesis stated earlier. The study has reveled the following:

- Since the annual average landing along the upper East Coast is much less than the potential fishery resources estimated by different workers as well as estimates of exploitable potential and MSY made in this study, there is no reason to state that the overall yield and pattern of exploitation are biologically unsustainable. (However individual species may be subjected to greater fishing pressure, the status of which may become evident only by in-depth biological studies).

- The results of performance analyses and market dependencies indicate that technology of mechanized trawling is not economically sustainable. In addition, the various factors of sustainability also confirm the overall adverse impact of trawling.

Clearly, in the case of mechanised fishing, it could be concluded that economic over-fishing has taken place before severe biological over-fishing could occur, indicating an immediate need for rationalising the fishing effort. The optimum combination of fleet estimated for exploiting MSY obviously is probably the answer. The question of how to regulate the fishing effort to the desired level is the challenge for the fishery managers.

9.3. Challenges in Fisheries Regulation

An important challenge is to establish the right institutional framework in which the industry operate to provide appropriate incentives to conservation of fish stocks and limiting fishing capacity to what is strictly needed (Hannesson, 1996). It is necessary to examine whether the existing institutional and regulatory framework is capable of meeting this important challenge.

Coastal marine fishery is a State subject and the various fishing related activities come under the administrative purview of the maritime States. The central department of fisheries under the MoA prepares the annual development plan for the country and implements the same through the respective States. Excepting Gujarat, all maritime States have enacted Marine Fishing Regulation Acts (MFRAs), which provide rules to regulate and manage the spatial distribution of different types of fishing effort of coastal fisheries within the territorial limits (Vijayakumaran and

Bhargava, 2001). However, the implementation of the same is not satisfactory because of several reasons:

- The awareness of various provisions of MFRA is poor among fishermen.
- The fishing vessels lack gadgets like GPS or Echosounder to determine the exact position or depth of operation.
- Fishermen tend to give importance to the spatial availability of fish than the rules.
- Patrolling and enforcement machinery is very weak.

There are inter-state variations in provisions of MFRAs. Fishing units seldom confine operations within their state boundaries. Though there is provision under MFRAs for issuing *licence,* it neither control the quantity of the catch (quota) nor there is any limits to number of licences to any type of fishing units. The existing regulatory framework and institutional mechanism is inadequate to face the challenges in control of fishing effort for sustainable resource management. It is noteworthy that the Fishing Policy 2004 calls for a review of the situation and prescribes a fresh model bill on coastal fisheries development and management.

9.3.1. Marine Fishing Policy 2004

The Marine Fishing Policy announced by the Government of India in November 2004 (MoA, 2004) is somewhat comprehensive in the sense that it covers all sectors and stakeholders and envisages a harmonious development of marine fishery in both territorial and extra-territorial waters. The policy objectives are:

- to augment marine fish production of the country up to the sustainable level in a responsible manner so as to boost export of seafood from the country and also to increase per capita fish protein intake of the masses,

- to ensure socio-economic security of the artisanal fishermen whose livelihood solely depends on this vocation.

- to ensure sustainable development of marine fisheries with due concern for ecological integrity and biodiversity.

The policy advocates protection, consideration and encouragement of subsistence level fishermen, technology transfer to small-scale sector and infrastructure support to industrial sector. The proposal to earmark exclusive area in terms of depth and (or) distance for non-mechanised (non-motorised) traditional craft and categorisation of motorised units with mechanised units is a new idea likely to create fresh area of conflict. Considering the inter-state variations in fishing zones, effort will be made to harmonise the pattern of demarcation in different states. The policy envisages limiting motorisation to about 50 percent of traditional craft allowing the remaining to carry on subsistence fishing in the nearshore waters.

The policy also envisages to providing incentives for acquisition of multi-day fishing units to encourage the small-mechanised sector, which is an undesirable option. Assessment of existing fishing capacity and capacity based regulation of effort is very much needed for the fishery of the upper East Coast.

9.3.2. Suggestions

There are some other important suggestions for the long run sustainability of the fisheries and welfare of the fishing communities of the upper East Coast of India.

- Initiate fishing capacity assessment and set limits to issue of licence to different types of fishing units based on the resource potential and other socio-economic criteria.

- Rationalise the assistance given under various schemes based on overall socio-economic cost and benefits and avoid improper incentives. Devise schemes to decommission or disinvest excess fishing vessel rather than providing subsidies on capital and operational inputs.

- Define regulatory boundaries based on the resource boundaries with the help of scientific information and fishermen's opinion rather than blindly following the geo-political boundaries.

- Establish regional fishery management bodies for sustainable management of resources within the wider areas (like UEC) with participation of stakeholder representatives from all maritime states.

- There is an urgent need to enhance the coastal resource base especially on land for alternate employment avenue and livelihood support to dependent coastal communities. The strategic planning should consider breaking the cultural barriers to equip the fishermen with necessary education, skill and change in attitude to embrace new avenues of employment.

- Promote co-operative development fully utilising the credit facilities extended by NCDC, especially in Orissa and Andhra Pradesh. From 1974 up to 2004-05, the sanctioned assistance from NCDC to Andhra Pradesh and Orissa was Rs.7109.9 lakh and Rs.561.6 lakh compared to 23374.1 lakh sanctioned for West Bengal[1]. Utilisation of funds also is far less in Andhra Pradesh (Rs.4719 lakh) and Orissa (Rs.279 lakh) compared to West Bengal (Rs.17281 lakh).

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[1] Source. Mr. Bijoy George, NCDC, Thriuvananthapuram;

- Develop and strengthen internal marketing infrastructure parallel to promotion and value addition of export commodities. Develop adequate transport facilities as well as hygienic handling of fish.

- Provide basic amenities for health, sanitation and education of fishermen communities and build their capacity to understand the issues and find solutions.

In the long run, granting of secure rights to resource users (individually or collectively) for use of a portion of the catch, space or relevant aspect of the fishery is one of the ideal methods for sustainable fishery management. The individual (group) will be responsible and would be able to restrict the exploitation to the level, which gives him (them) maximum benefit. Participatory management and Co-management are two emerging approaches in fisheries management. There is a need for granting of meaningful role to stakeholders in the full range of management (e.g. Planning, science, legislation and implementation). The role of NGOs and other stakeholder participation in the development has figured in the Policy 2004.

9.4. Limitations of the Present Study

The present study has mainly considered the important classes of vessels engaged in active demersal trawl fishing and those forming a significant fleet influencing the overall yield from the fishery. Finer details of some individual classes of vessels could not be delineated from the pooled information. The major limitations of this study are with regard to the variability in the biological, technological as well as economic variables in time and space.

- Characteristics of the fishery resources may change in response to the changes in the environment as well as exploitation pattern.
- Changes in the technology and application of technology or development of infrastructure may influence the economy of operation of fishing units.

- The changes in the post-harvest technology and pattern of utilisation, change in demand and prices, opening up of new markets etc. may cause change in the parameters derived in this work.

In such cases the different biological, technological and economic parameters may need revalidation. The interpretations and suggestions in this thesis have to be considered with these limitations in mind.

9.4.1. Areas of Future Research

The fundamental requirement for the management of the fishery resources is the acceptance that there is a management problem and it is necessary to resolve them adopting scientific methodologies. If scientists are made responsible for suggesting solution space, policy makers adopt them to evolve feasible measures and administration take the responsibility of implementing the same, avenues for productive research will open up. Identifying the lacunae in research and focussing attention to develop a strong scientific knowledge base on various aspects of the fish stocks and fishery environment is essential. From the analysis of the fisheries of the upper East Coast of India it has become clear that research in some important areas is wanting. Some of these areas are detailed below:

Most of the studies on fishery biology and population dynamics have been confined to a limited time/space. It must be noted that neither the species, nor the factors controlling its abundance are limited to the time/space frame chosen. Extrapolation of the results to a wider frame of time/space is extremely erroneous. Knowing the inherent problems of limited area studies, the concept of Large Marine Ecosystem (LME) as a basic unit of study is being accepted all over the world. The initiative taken to study Bay of Bengal Large Marine Ecosystem (BOBLME) will get better results when the expertise and resources of different agencies are pooled up (Vijayakumaran, 2002).

The current knowledge about the dynamics of the multi-species multi-gear fishery of the Indian waters is quite inadequate. There is a lot of research work to be done on species interaction, species succession, predator- prey relationship, trophic interaction, energy budget, larval abundance and their survival, variability in the relation to oceanic processes and in the context of global climate change etc. It is high time that researchers' attention is turned on these crucial areas where significant works are wanting in this region.

Considerable time has to be spent for data collection and analysis even using macro models. The status of fisheries may deteriorate further before the models are applied and any warning signals are given for necessary policy initiatives. In view of this, development of some simple and effective indicators for ecosystem status, sustainability and level of fishing, which can be easily applied is imperative. Froese (2004) has suggested three indicators to deal with overfishing.

Price of fish is the most important factor deciding the economy of operation of fishing units. As mentioned in an earlier Chapter research in economics, pricing, marketing etc. of marine fishing is an area where very little attention is being paid. As this information is vital, a permanent mechanism to monitor these aspects on a continuing basis is necessary. Similarly development of proper market intelligence, market tools and support systems is necessary for proper development of a sustainable fishery system. Market incentives are to be provided in appropriate situations for addressing factors of unsustainability. In the absence of proper support price to fishery products, capture and landing of non-conventional varieties from the offshore waters will never materialise. There is a need for enlarged interest in the research on the market and economic aspects.

Development programmes and allocation have to commensurate with sectoral contribution to the economy and measures should be evolved to prevent resource drain. Efforts must be made to develop and use economic tools to ensure distribution of the benefits form the fishery to address community issues and economic sustainability

Social aspects of fisheries, especially the implications of various policies, outcome of current polices and programmes are very important. Assessment of ongoing programmes and impact analysis of policies must figure prominently in the research agenda. Understanding the social and environmental cost involved and development and application of tools to internalise externalities are necessary for proper management and sustainable development of fisheries.

There must be an integration of social, economic and biological research to draw synergy for sustainable development. Reviewing the current state of development and application of knowledge in the marine fisheries, Vijayakumaran (2001) has suggested a paradigm shift in the fisheries research and development. Proper support must be given to development of scientific knowledge on various dimensions, integrating them and transfer of this knowledge to the level of planning and implementation. Capacity building and raising public awareness of development and application of programmes has to be an important programme in the agenda.

□□□

Appendix –A

QUESTIONNAIRE FOR OBTAINING TECHNICAL AND ECONOMIC INFROMATION FROM FISHING UNITS

	Questionnaire Code No.			
1.	**GEORAPHICAL LOCATION**			
	1.1. Landing Centre/ Harbour ⇓	1.2. District ⇓	1.3. State ⇓	
2.	**OWNERSHIP & ACQUISITION**			
	2.1. Name of the owner (S) /Company ⇒			
	2.2. Type of ownership ⇒			
	2.3. Mode / Source of Finance ⇒			
	2.4. Year of Acquisition/ Construction ⇒			
3.	**FEATURES AND DIMENSIONS**			
	3.1. Type of the vessel ⇓	3.2. Overall length (LOA) m ⇓	3.3. Fishing Method ⇓	
4.	**ENGINE AND POWER**	Main Engine ⇓	Auxiliary I ⇓	Auxiliary II ⇓
	4.1. Engine make and Horse Power ⇒			
	4.2. Fuel consumption (litre /hour) ⇒			
5.	**CAPACITIES AND FACILITIES**			
	5.1. Fuel Tank (kl) ⇓	5.3. Fish Hold (t) ⇓	5.5. Freezing (tpd). ⇓	5.7.Cabin Berths (No) ⇓
	5.2. Freshwater (t) ⇓	5.4. Ice Box (t) ⇓	5.6.RSW (t) ⇓	5.8. Endurance (d)⇓
6.	**COMMUNICATION/NAVIGATION/SAFETY EQUIPMENTS**			
	6.1. Navigation / Communication ⇓	6.2. Fish-finding/ Depth recording ⇓	6.3. Life-saving gadgets ⇓	
7.	**FISHING EQUIPMENT/GEAR**			
	7.1.Type and specifications of Net ⇒			
	7.2. No. of nets operated at a time ⇒		7.3. No. of nets carried onboard ⇒	
	7.4. Wire rope length (m) ⇒		7.5. Depth range of operation (m) ⇒	
8.	**CREW AND SHORE STAFF (Numbers)**			
	8.1. Number of crew ⇓	8.2. Number certified crew ⇓	8.3. Number of shore staff ⇓	

9	**OPERATIONAL DETAILS** (Average numbers of days and hours)		
	9.1. Voyages per year ⇓	9.2. Sea days per voyage ⇓	9.3. Fishing days per voyage
	9.4 Fishing hours per day ⇓	9.5 Closed season ⇓	9.6. Maintenance/Bad weather ⇓

	9.7. Area of operation ⇒			
	9.8. Distance from Port ⇒			

10.	**VOYAGES, CATCHES AND DISCARDS DURING RECENT YEARS**				
	Year ⇓	Voyages ⇓	Shrimp catch (t) ⇓	Fish Catch (t) ⇓	Discards (t) ⇓

11.	**CATCH COMPOSITION :** Major components of the fish and shellfish catch (%)					
	Species/group ⇓	% ⇓	Species/group ⇓	% ⇓	Species/group ⇓	% ⇓

12.	**CAPTIAL INVESTMENT (Rs)**			
	12.1. Vessel (Hull) ⇓	12.2. Engine ⇓	12.3. Gears ⇓	12.4. Other items ⇓

14	**FIXED COSTS PER YEAR (Rs)**			
	14.1. Insurance ⇓	14.2. License fee ⇓	14.3. Port charge ⇓	14.4. Overheads ⇓

15.	**WAGES & ALLOWANCES (Rs)**				
	Year ⇓	Salaries (Crew) ⇓	Mess Allowance ⇓	Incentive ⇓	Salaries (Staff) ⇓

16	**COST OF CONSUMABLES (Rs)**					
	Year ⇓	Fuel ⇓	Oil ⇓	Water ⇓	Ice ⇓	Others ⇓

17	**OTHER RECURRING COSTS (Rs)**				
	Year ⇓	Repair ⇓	dry-docking ⇓	Replacement of gear ⇓	Miscellaneous ⇓

18.	**REVENUE (Rs)**				
	Year ⇓	Shrimp sales ⇓	Fish Sales ⇓	Other income ⇓	Total Income ⇓

	Remarks

Appendix - B

MODELS IN STOCK ASSESSMENT

Many models have been developed for assessment of fish stocks to facilitate the estimation of various parameters for management decisions. The major category of stock assessment models is deterministic, which can be further divided into macro-analytic and micro-analytic models. Stochastic models incorporating random elements in the deterministic models are also attempted by many workers.

B.1. Macro-analytic models

The deterministic macro-analytical models, which normally require catch and effort data, are simpler and straightforward with regard to collection and analysis of data. Russell (1931) gave the underlying basic concept for these models as:

$$\Delta B = B_1 - B_0 = R + G - D \qquad \ldots (1)$$

Where B denotes the biomass, R is the recruitment and G is the growth and D is the removal (predation, emigration etc.). Two other parameters that are considered in the macro-analytical models are the yield Y and the instantaneous fishing mortality F. The important macro-analytical models are discussed below.

B.1.1. Swept Area Method

This method is most relevant to assessments based on the trawl fishing surveys. Let a be the area swept by one unit of effort; A – the total area inhabited by the stock in question; X, the escapement factor (the fraction of fish caught by unit effort) and c, the catch per unit effort during the period of survey. Then the stock size B is given by:

$$B = \frac{c.A}{X.a} \qquad ...(2)$$

The area a swept by one unit of effort is given by

$$a = t.v.w \qquad ...(3)$$

where, t is the time spent for trawling, v the velocity of the fishing vessels (trawling speed) and w the width of the area swept by the net (generally the head-rope length). It is clear from the above that the expected yield for the gears from the entire area is

$$Y = FB = XB = \frac{c.A}{a} \qquad ...(4)$$

B.1.2. Biomass approach

This method makes use of the relation between instantaneous fishing mortality rate F, natural mortality M, intrinsic rate of increase in population $r_{m.,}$ the carrying capacity of the water body B_{oo} and the virgin biomass B_v (Gulland, 1971[b]). Thus the stock size B and MSY are given by the formula:

$$B = Y / F \qquad ...(5)$$

$$MSY = r_m.B_\infty / 4 \qquad ...(6)$$

$$MSY = 0.5.MB_v \qquad ...(7)$$

B.1.3. Surplus Production Model

Removal of the fish through capture reduces the biomass of the stock, the rate of removal being equal to or greater or less than the rate of increase in biomass through growth and recruitment, which in turn is decided by the intrinsic nature of the stock. If rate of removal equals the rate of increase in biomass, the quantity caught is called equilibrium catch *ye*. The surplus production model can be expressed as:

$$\frac{1}{\overline{B}}\frac{(\Delta B)}{\Delta t} = f(\overline{B}) - F \qquad \text{...(8)}$$

Where $\overline{B}$ is the mean biomass during the time interval Δt and $f(\overline{B})$, the rate of natural growth and F the rate of catch removal. Hence,

$$\Delta\overline{B} = \overline{B}\Delta t(f(\overline{B}) - F) \qquad \text{...(9)}$$

Under equilibrium condition $\Delta\overline{B}$ is equal to zero. Hence the condition for equilibrium is are given as:

$$f(\overline{B}) = F \qquad \text{...(10)}$$

and the equilibrium catch Y_e (using eq.10)

$$Y_e = F\overline{B}\Delta t = \overline{B}f(\overline{B})\Delta t \qquad \text{...(11)}$$

B.1.3.a. The Schaefer Model

The intrinsic rate of natural growth depends on the biomass since it decreases or increases with the decrease or increase in the biomass. As a first approximation let the relation be linear and thus when a stock is exploited the biomass decrease. Hence according to Schaefer (1954),

$$f\overline{B} = m - K\overline{B} \qquad \text{...(12)}$$

When $\overline{B}$ has reached its maximum B_∞, then

$$f(\overline{B}) = 0.$$

$$\text{Hence } m = KB_\infty \text{ and } f(\overline{B}) = K(B_\infty - \overline{B}).$$

Under equilibrium condition,

$$f(\overline{B}) = F \text{ and } Y_e = F\overline{B}$$

Hence,

$$Y_e = K\overline{B}(B_\infty - \overline{B}) \qquad \text{...(13)}$$

This equation leads to the famous logistic growth curve where

$$\frac{dB_t}{dt} = kB(B_\infty - \overline{B})/B_\infty,$$

$$K = kB_\infty$$

Leading to,

$$B_t = B_\infty / \{1 + \exp[-k(t - t_0)]\} \qquad \text{...(14)}$$

From the above model, one can obtain MSY (Y_{max}) and the corresponding effort (F_{max}) by equating $dY_e / dB = 0$. The equations satisfying the equilibrium conditions are:

$$\left.\begin{aligned} \overline{B} &= B_\infty - \frac{F}{K} \\ Y_e &= F(B_\infty - \frac{F}{K}) \end{aligned}\right\} \qquad \text{...(15)}$$

$$= K\overline{B}\left(B_{\infty} - \overline{B}\right)$$

Hence,

$$\left.\begin{aligned} F_{\max} &= KB_{\infty}/2 \\ B_{\max} &= B_{\infty}/2 \\ \text{And } Y_{\max} &= KB_{\infty}^{2}/4 \end{aligned}\right\} \qquad \ldots(16)$$

B.1.3.b. Exponential Model

In place of the linear relationship assumed in the above between $f(B)$ and B empirical data has indicated non-linear relationship. Hence, Garrod (1969) and Fox (1970) suggested an exponential relationship.

$$f\left(\overline{B}\right) = m - K.\ln\overline{B} \qquad \ldots(17)$$

In this case, the equations under equilibrium conditions are:

$$\left.\begin{aligned} \overline{B} &= B_{\infty}\exp\left(-\frac{F}{K}\right) \\ Y_{e} &= FB_{\infty}\exp\left(-\frac{F}{K}\right) \\ &= K\overline{B}.\ln\left(B_{\infty}/\overline{B}\right) \end{aligned}\right\} \qquad \ldots(18)$$

Leading to

$$F_{\max} = K, \quad B_{\max} = B_{\infty}/e \text{ and } Y_{\max} = KB_{\infty}/e$$

B.1.3.c. Pella and Tomlinson Model

Generalizing the above assumption, Pella and Tomlinson (1969) proposed the following model

$$f(B) = K\left(B_{\infty}^{m-1} - \overline{B}^{m-1}\right) \qquad \ldots(19)$$

The equations under equilibrium conditions are:

$$\left.\begin{aligned}\overline{B} &= (B_{\infty}^{m-1} - \frac{F}{K})\frac{1}{m-1} \\ Y_e &= F(B_{\infty}^{m-1} - \frac{F}{K})\frac{1}{m-1} \\ &= K\overline{B}(B_{\infty}^{m-1} - \overline{B}^{m-1})\end{aligned}\right\} \quad \ldots(20)$$

Leading to

$$F_{\max} = K\frac{m-1}{m}B_{\infty}^{m-1}, \quad B_{\max} = B_{\infty}\left(\frac{1}{m}\right)^{\frac{1}{m-1}} \text{ and } Y_{\max} = K\frac{m-1}{m}B_{\infty}^{m}\left(\frac{1}{m}\right)^{\frac{1}{m-1}}$$

B.1.4. Successive Removal Methods

Under this group, it is assumed that the change in the stocks is only due to catch removals and during fishing no other change takes place.

B.1.4.a. Leslie method

Assuming catch per unit of effort as an index of stock abundance, Leslie (1952) proposed the following model:

$$\frac{C_t}{f_t} = q.N_t \quad \ldots(21)$$

Where C_t is the catch, f_t the fishing effort, N_t the mean population size during t and q the catchability coefficient. Now,

$$N_t = N_0 - K_t \quad \ldots(22)$$

Where N_0 is the initial size of the stock and K_t the cumulative catch to the start of the interval plus half that taken during the interval. Hence,

$$\frac{C_t}{f_t} = qN_o - qK_t \quad \ldots(23)$$

which is linear in K_t and C_t / f_t. Thus the parameters N_0 and q can be estimated from equation (23).

B.1.4.b. De Lury Method

A slight modification in the Leslie Method, detailed above leads to that of De Lury (1951). Taking

$$\frac{C_t}{f_t} = q.N_o \frac{N_t}{N_0} \qquad ...(24)$$

and assuming that the fraction of stock taken by a unit of effort is small, for example 0.02 or less, we have,

$$N_t = N_0 \exp(-qE_t) \qquad ...(25)$$

Where E_t is the cumulative fishing effort up to the start of the interval t plus half that taken during that interval. From equations (24) and (25), and taking logarithms, we get

$$\begin{aligned} \ln(C_t / f_t) &= \ln(qN_0) + \ln(N_t / N_0) \qquad ...(26) \\ &= \ln(qN_0) - qE_t \end{aligned}$$

Thus equation (26) is linear in cumulative effort E_t and $\ln(C_t/f_t)$ and q and N_o can be estimated in the usual way.

As long as there is no error in K_t, Leslie method provides unbiased estimates of q and N_0. In the case of De Lury method effective fishing effort tends to be less accurate than catch statistics and since the relative errors of ln (C_t / f_t) and E_t will usually be unknown. It may not be possible to obtain unbiased estimates of q and N_0. Hence Leslie method is generally preferable.

B.1.4.c. Ricker Method

This method also is a successive removal method and similar to the Leslie method.

$$N_0 - K_t = N_0 (1-q)^{E_t} \qquad ...(27)$$

Hence from equation (23),

$$\frac{C_t}{f_t} = q(N_0 - K_t) = qN_0(1-q)^{E_t} \qquad 28)$$

Taking logarithms, this leads to

$$\log(C_t/f_t) = \log(qN_0) + E_t \log(1-q) \qquad \ldots(29)$$
$$= \log(qN_0) - qE_t$$

This determines a straight-line whose slope estimates the catchability (q) of the fish and whose ordinate intercept estimates log N_0 where N_0 is the original population.

B.1.5. Capture Recapture Methods

This is another important class of models, which include the simple hypergeometric model in single release of marked ones to methods covering multiple release and recapture system both in closed and open populations. For obtaining valid estimates of the stock size N, the important models in stock assessment in closed populations assume the following:

i) The population is closed and hence N is constant
ii) All animals whether marked on not have the same probability of being caught and
iii) There is no loss in marks during the interval between the sampling period and at the reporting stage.

Under the above assumptions, suppose n_1 animals are taken from, marked and released into a population of N animals. Then a second sample of n_2 animals is taken after allowing sufficient time for marked animals to mix with the rest. Suppose m_2 animals are found marked in the second sample. Then Peterson estimate is:

$$\frac{m_2}{n_1} = \frac{n_2}{N} \quad \text{or} \quad \hat{N} = \frac{n_1 n_2}{m_2}$$

A number of models such as hypergeometric model, Baily-inverse sampling method, the generalized hypergeometric model, inverse Schnabel census are detailed in this category. Since these are not of much relevance in the present context, they are not dealt in detail.

B.1.5.a. Relative response Model

This model depends on successive catches to predict the maximum catch that the fishery can sustain. There are three assumptions (Alagaraja, 1984) for success of this model. These are:

1) Various types of gears that are not species specific exploit stocks existing in a particular area. This implies that the effect of fishing a mixture of stocks by these gears is proportional to the relative abundance of stocks in the mixture.
2) The fishing is increased over a period of time till the optimum level is achieved.
3) When the effort is increased the catches also increase till maximum level is reached but the rate of increase increases first then decreases and finally reaches zero.

In progressive fisheries where multispecies are exploited by multigears and where evaluation of effective effort poses problems particularly in tropical fisheries, this model is useful. The model is:

$$C_t - C_{t-1} = f(C_{t-1}) \qquad ...(30)$$

A simple version of the above is a linear relationship between the successive catches, given as:

$$C_{t+1} = a + b\, C_t \qquad ...(31)$$

In the progressive fishery, the level of maximum catch can be predicted and suitable management measure could be suggested in advance to get sustainable yield from the fishery. The equation (1) is the same form as the well-known von Bertalanffy's growth model. Hence in the notation of equation (1),

$$C_{t+1} = C_{max}\,(1-e^{-k}) + C_t\, e^{-k} \qquad ...(32)$$

And

$$C_{max} = a\,/\,(1-b) \qquad ...(33)$$

In addition to the above methods, there are some quick estimation methods such as comparison method, indicator method, productivity approach etc. These methods are used in specific cases with limited practical application.

B.2. Micro-analytic Models

Unlike the macro-analytic models, micro-analytic models (also called the dynamic pool models) take into account recruitment, mortality age growth and other factors affecting the stock. The models discussed here are based on two major assumptions:

i) The stock is in a steady state (or equilibrium) in other words, recruitment, growth and mortality are constant. This results in an annual yield from a cohort during its entire life span.

ii) The yield is directly related to recruitment.

Under these assumptions it is clear that the yield per recruit (Y/R) is an index of the stock and attempts are made to estimate Y/R to study the condition of the stock exploited. The most widely used model is the Beverton and Holt (1957) model.

B.2.1. Beverton and Holt Model

Let N_t be the number of fish alive at age t, M and F the instantaneous rate of natural and fishing mortalities respectively and W_t, the average weight of a fish at age t. Then in the interval t, $t+\Delta t$, the numbers ΔC_t and weight ΔY_t, which are caught, are given by

$$\Delta C_t = FN_t\, \Delta t \text{ and } \Delta Y_t = FN_t\, W_t \Delta t$$

Suppose t_r is the age at recruitment and t_i the total life expected then catches during this life-span are denoted by:

$$c = \int_r^{t_i} dc_t = \int_r^{t_i} FN_t dt$$

And

$$y = \int_r^{t_i} dy_t = \int_r^{t_i} FN_t W_t dt$$

Though fish is available in the fishing ground at the age t_r its size at first capture depends on the gear employed. Suppose the age at first capture be t_c then from t_r to t_c no fishing mortality takes place and only from t_c onwards fishing mortality along with natural mortality takes place in the stock. Hence we have $F = 0$ and $Z = M$ when $t \leq t_c$. For $Z = F+M$ when $t > t_c$. Let R be the recruits at t_r. Then

$$N_t = R.\exp[-M(t-t_r)] \text{ for } t \leq t_c$$

If R' is the number of fish at $t = t_c$ then,

$$N_t = R'.\exp[-Z(t-t_r)] \text{ for } t>t_c$$

Where

$$R' = R.\exp[-M(t_c - t_r)]$$

In these notations the number of fish caught is

$$C = \int_c^{t_L} R' F \exp[-Z(t-t_c)]dt$$

$$= R'\frac{F}{Z}(1-\exp[-Z(t_i - t_c)])$$

$$= R\frac{F}{Z}\exp[-M(t_c - t_r)]\{1-\exp[-Z(t_L - t_c)]\} \qquad \ldots(34)$$

When t_L is sufficiently large then the last term becomes negligible and

$$C = R\frac{F}{Z}\exp[-M(t_c - t_r)]$$

$$= \frac{F}{Z}R' \qquad \ldots(36)$$

The catch in terms of weight can be obtained once time-weight relationship is known. For this purpose the following von Bertalanffy's, growth equation.

$$W_t = W_\infty\left[1-e^{-k(t-t_0)}\right]^3 \qquad \ldots(37)$$

is used.

This may be rewritten as:

$$W_t = W_\infty \sum_{n=0}^{3} U_n \exp[-nk(t-t_0)]$$

Hence

$$Y = \int_c^{t_L} FR'W_\infty \exp[-Z(t-t_c)]\sum_{n=0}^{3} U_n \exp[-nk(t-t_0)]dt$$

On integrating we get,

$$Y = FR'W_\infty \sum_0^3 \frac{U_n}{Z+nk} \exp[-nk(t_c - t_0)] \times \{1 - \exp[(Z+nk)(t_L - t_c)]\} \qquad \ldots(38)$$

where $U_0 = 1$, $U_1 = -3$, $U_2 = 3$ and $U_3 = -1$. When t_L is sufficiently large, the last term becomes negligible and we have,

$$Y = FR'W_\infty \sum_0^3 U_n \exp[-nk(t_c - t_0)]/(z+nk)$$

$$= FR.\exp[-M(t_c - t_r)]W_\infty \sum_0^3 U_n \exp[-nk(t_c - t_0)]/(z+nk)$$

The yield per recruit thus becomes

$$Y/R = F\exp[-M(t_c - t_r)]W_\infty \sum_0^3 U_n \exp[-nk(t_c - t_0)]/(z+nk) \qquad \ldots(39)$$

Since this is a function of *F*, t_c and *Y/R*, the effect of gear both in terms of intensity (*F*) and size at first capture (t_c) on *Y/R* could be studied. Accordingly useful suggestions on the effort imposed on fishery can be given. This is straightforward and elegant. Yield Tables are available (Beverton and Holt, 1964) to draw yield isopleths for drawing conclusions from the nature of existing fishery.

B.2.2. Jones Method

In equation (37) isometric growth is assumed and hence cube law is suggested for growth in weight. In general assuming allometric growth (37) can be written as:

$$W_t = W_\infty \left[1 - e^{-k(t-t_0)}\right]^b \qquad \ldots(40)$$

In this case, yield per recruit integral becomes an incomplete beta function of the form

$$Y/R = (F/k)\exp[-M(t_c - t_r) + Z(t_c - t_0)]W_\infty \int_0^\varepsilon x^{p-1}(1-x)^{qp-1}\,dx \qquad \ldots(41)$$

where p = z/k, q=b+1 and $z = \exp\{-k(t_c - t_0)\}$

B.2.3. Ricker Model

Ricker (1975) proposed a simpler method with no assumption on the form of growth. Using Y=FB, he suggests

$$Y_E = \sum_{t=t_c}^{t_L} F_t \overline{B}_t \qquad \text{...(42)}$$

As a first approximation $\overline{B}_t$ is the average of initial and final biomass indicated by

$$\overline{B}_t = (B_t + B_{t+1})/2 = B_t[1 + \exp(G_t - Z_t)]/2$$

where G_t and Z_t are instantaneous growth and mortality rates respectively. Hence the yield equation becomes:

$$Y_E = \sum_{t=t_c}^{t_L} F_t B_t [1 + \exp(G_t - Z_t)]/2$$

If a stock were to increase or decrease exponentially, then

$$\overline{B}_t = B_t[\exp(G_t - Z_t) - 1]/(G_t - Z_t) \qquad \text{...(43)}$$

This can be substituted in (42) and obtain the corresponding yield equation.

B.2.4. Cohort Analysis

Demographic composition of a cohort with the corresponding rates of mortalities determines more precisely the condition of a stock. Catches at regular intervals (annual) taken from a single cohort are useful to estimate the abundance of the stock and the fishing mortality. In this type of analysis the estimates of stock size at each age/size are estimated backward finally arriving at the initial stock size. For this purpose the instantaneous rates of natural (M) and fishing (F) mortalities are assumed to be known. Let N_i be the number of fish at the i^{th} period; S_i the rate of survival; D_i the number that die and C_i the catch during the period i. Hence we have

$$N_{t+1} = N_t S_t \ ; \ D_t = N_{t-1} \ ; \ S_t = \exp(-Zi)$$

where $Z_i = F_i + M_i$; $D_i = Z_i N$ and $C_i = F_i \overline{N}_i$

using

$$C = (F_i / Z_i) N_i [1 - \exp(-Z_i)] \qquad \text{...(62)}$$

and the above relation leading to $N_i = D_i/(1-S_i)$

where Di = $Z_i \overline{N}_i$ and $\overline{N}_i = C_i / F_i$, from the initial values of C_i, M_i and F_i successive stock abundances can easily be estimated. A slight modification in this approach is suggested by Pope (1972) otherwise called virtual population analysis (VPA).

There are many other models used for fish stock assessment. Application Stochastic models are not much successful because of difficulty in obtaining data for use in such models. Ecosystem modelling being attempted by many workers to have holistic picture of the system is also having a number of limitations. However, increasing awareness and availability of powerful computers are likely to lead to development of better models.

□□□

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Legend to Plates 1 - 6

Plate - 1	*A good haul of lesser sardine, a major pelagic resource along the upper East Coast.*
Plate - 2	*Spotted seerfish, one of the highly demanded table fish and an important fishery supporting traditional gears.*
Plate - 3	*Baskets of Indian drift-fish, a cheap and tasty deeper water table fish, being unloaded from a boat.*
Plate - 4	*A Sona trawler just returned from voyage with a variety of fish dried on the top of the wheelhouse, making best possible use of the catch.*
Plate - 5	*A large sailfish caught in hooks and line being carried from the boat by two fishermen at Lawsons Bay, Visakhapatnam. Fibreglass catamarans used for hooks and line operation are seen in the background.*
Plate - 6	*Yellowfin tuna, a highly priced fish in the Japanese market, being brought for sale at Visakhapatnam Fisheries Harbour.*

PLATE - 1

PLATE - 2

PLATE - 3

PLATE - 4

PLATE - 5

PLATE - 6

Legend to Plates 7 - 12

Plate - 7	*Mini trawlers and large trawlers berthed at Visakhapatnam Fisheries Harbour, waiting for the end of closed season.*
Plate - 8	*A mechanised gill-netter unloading its Hilsa gill-net at Fishing Harbour, Dhamara, Bhadrak District, Orissa.*
Plate - 9	*Crew of a fibreglass boat preparing to go for the daily fishing at Lawsons bay, Visakhapatnam.*
Plate - 10	*A group of fishermen hauling up a beach seine, a seasonally operated traditional gear, at Visakhapatnam.*
Plate - 11	*Large mechanised gill-netters berthed at the Fisheries Jelly at Frazergunj, West Bengal.*
Plate - 12	*A view of Paradeep Fisheries Harbour, Orissa with fibreglass IBM boats in the foreground and trawlers berthed in the background.*

PLATE - 7

PLATE - 8

PLATE - 9

PLATE - 10

PLATE - 11

PLATE - 12

Legend to Plates 13 - 18

Plate - 13	*A good haul from a boat-seine, inside a plank-built boat being taken for auction.*
Plate - 14	*Fisherwomen making lots of dried fish ready for sale at the Fisheries Harbour, Visakhapatnam.*
Plate - 15	*Workers busy sorting and grading of fish in the morning hours at Paradeep Fisheries Harbour, Orissa.*
Plate - 16	*An insulated truck at Visakhapatnam Fisheries Harbour being loaded with the trawl catch for transport to distant markets.*
Plate - 17	*Fisherwomen selling fresh seerfish and mackerel at the Fisheries Harbour, Visakhapatnam*
Plate - 18	*A women selling assorted fish at the evening market at Padhuan, Balasore District, Orissa.*

PLATE - 13

PLATE - 14

PLATE - 15

PLATE - 16

PLATE - 17

PLATE - 18

GLOSSARY OF TERMS

Active fisherman	A fisherman who actually spends major part of his working time in fishing and fishing related activities. (Distinguished as full time and part-time).
Adaptive (or experimental) management	Management involving active response to new information or the deliberate manipulation of fishing intensity or other aspects in order to learn something of their effects within a stock, several sub-stocks (can be regarded as experimental units), in which alternative strategies (different fishing intensities or combination of techniques, for example) are applied.
Artisanal fishery	(Traditional fishery) A small-scale, low cost and labour intensive sector of the marine fishery comprising mainly of non-mechanised or motorised fishing units engaged in near-shore fishing using indigenous fishing technologies and catering to the local markets.
Biodiveristy	(Biological diversity) the variety of living material in terms of genes, species and ecosystems within a given area.
Biological sustainability	(Bioecological sustainability) a state where the current catch level can be maintained indefinitely and the stock size do not change from year to year. This catch level may be at an optimal or sub-optimal level (see also maximum sustainable yield)
Biological reference point	Particular value of stock size, catch, fishing effort and fishing mortality, which may be used as a goal in fisheries management.
Biomass	The sum of weights of individuals in a fish stock.
Break-even	The point where revenue equals costs.
Bycatch	The part of the catch that is taken incidentally to the target species, and of which some (trash fish) may be discarded.
Catch	Amount of fish caught; the product of applying effort to fish stock. Catch can be either discarded or landed.
Catchability coefficient (q)	The proportion of the total stock caught by one unit of fishing effort.
Catch quota	The maximum catch permitted to be taken from a fishery; such a limit applied to the total catch from a fishery is often referred to as a global quota (as distinguished from individual quota).

Cephalopods	Mollusks (having feet on head) consisting of squids, cuttlefish and octopus; having good value in the export market.
Closure	Banning of fishing during particular times or seasons (temporal closure) or in particular areas (spatial closure) or combination of both.
Co-management	(Cooperative management) either informal or legal arrangements between government representatives, community groups and other user groups, to take responsibility for and manage a fishery resource and/ or its environment on a cooperative basis.
Continental shelf (or shelf)	The sea bottom from the shore to a depth of 200 m (distinguished from continental slope, which is the sea bottom from 200 to 2000, m).
Craft	Any type of boat or boat-like floating constructions used for carrying men and material for fishing.
Critical habitat	Habitats (a place where a species normally lives) that are crucial in the life cycle of a marine species, typically nursery and spawning areas, such as estuaries, mangroves, seagrass meadows and reefs.
Crustaceans	Invertebrate animals with jointed external skeleton; including crabs, lobsters, shrimps (prawns) etc.
Decommissioning	The policy of withdrawing the boat (capital) from the fishery.
Demersal	Sinking or lying on the bottom; generally used to denote the fish present at or near bottom, relatively slow moving and comparatively slow growing (e.g. flat fish, goatfish, croakers etc.).
Density	The number or weight of organisms (or any other entity) per unit area or volume.
Discard	Difference between catch and landing.
Ecologically Sustainable Development (ESD)	Use of the environment that aims to meet present needs without compromising the ability of the future generations having the same privilege; development based on the sustainable use of both species and ecosystems, the maintenance of essential ecological processes and the preservation of biological diversity.
Economic sustainability	Those who harvest the resource are earning sufficient returns for their investment and labour and, ceteris paribus, will remain in the fishery in the long run.
Effort	The combined level of inputs employed in the fishery; usually expressed in terms of time fished (e.g. days).

Exclusive Economic Zone (EEZ)	An area of sea out to 200 nautical miles from coastline or outer reefs, in which an adjacent country has sovereign rights and responsibilities.
Finfish	Fishes (vertebrate, teleost) with fins (as distinguished from shellfish)
Fisheries regulations	Controls designed to restrict either effective fishing effort (input controls) or total catch (output controls) to predefined limits in a fishery.
Fishery	An area of fishing activity generally geographically based; encompass an entire stock or set of stocks that are exploited by fishing. Several fisheries can be superimposed upon each other if they are characterised by different gears fishing different stocks within the same geographical area.
Fishing mortality	The mortality that is caused by fishing.
Gear	A gadget used for capturing fish or other aquatic organisms (e.g. nets, lines, pots etc.).
Gill-net	A vertical wall of net (in wide range of mesh size) kept at a stipulated depth in the water column, by a combination of floats and sinkers and capturing fish by gilling (entangling); Gill-netter is a boat engaged in operation of gill net
Growth overfishing	A level of fishing in which young recruits entering the fishery are caught before they grow to an optimum marketable size; a level beyond that required to maximize yield (or value) per recruit.
Hull	The streamlined outer part of the body of the boat touching the water below and covered by a near-flat deck from above (housing engine, storage areas and tanks, crew cabins etc. within)
Inboard motored (IBM)	The motor of the boat is fixed inside the hull of the boat, with or without shelter, and propeller is positioned to the rear underwater of the hull through a relatively short shaft. Transmission is direct and rudder control is directly using a bar at the aft of the boat.
Incentive	(Crew share) share of the revenue given to the crew of the boat.
Individual transferable quota (ITQ)	A catch limit or quota allocated to an individual fisher, who then has a guaranteed share (which may be either harvested or traded) of the TAC of a particular resource.
Industrial fishery	(Mechanised sector) The sector of the marine fishery characterized by medium or large-scale, mechanised fishing units and involving modern energy intensive technologies in harvest, storage, post-harvest processing; catering to export and domestic markets.

Input controls	Limitations on the amount of fishing effort, restrictions on the number, type and size of fishing vessels or fishing gear, or on the fishing areas or fishing times in a fishery.
Joint-venture	A partnership between foreign and local fishers.
Landing centre	A place (generally waterfront) where boats are brought to land their catch.
Larva (*Pl.* Larvae)	The early life history stages between the times of hatching of egg and transformation to a juvenile, the latter a miniature replica of the adult.
Marine protected areas (MPA)	A marine reserve, park or other area protected from uncontrolled human access and use by the application of various restrictions on activities, development and exploitation.
Maximum economic yield (MEY)	The yield above which the revenue generated by a marginal increase in effort is less than the cost of that increase; the point at which profits earned in excess of those needed to cover all fishing costs is maximized.
Maximum sustainable yield (MSY)	Largest annual catch that may be taken from a stock continuously without affecting the catch of the future years; a constant long-term MSY is not a reality in most fisheries, where stock sizes vary with strength of year classes moving through the fishery.
Mechanised boat	The motor of the boat is fixed inside the hull of the boat, with shelter, and propeller is positioned to the rear underwater of the hull through a relatively longer shaft. Transmission is through gearbox, which allow use of power for winch operation. Rudder control is indirectly using a steering wheel in the wheelhouse of the boat.
Minimum mesh size	The smallest size of the mesh permitted in nets and traps; imposed on the basis that smaller individuals will escape unharmed.
Mortality rate	The percentage of individuals in a population that die within a time interval (contrast to survival rate).
Multi-species multi-gear fishery	A fishery characterized by several species being harvested simultaneously by a single gear type; different gear types are applied to harvest the several species in different combinations.
Natural mortality	The mortality caused by natural factors such as senility, diseases, predation etc.
Open access fishery	A fishery with no restriction on the number of fishers or fishing units; an unmanaged fishery.

Outboard Motored (OBM)	The motor of the boat is removable and is fixed at the hind portion of the hull and propeller is attached to the engine proper with or without a shaft. Transmission is direct and rudder control is by tilting and turning the engine on its pivotal base.
Overcapitalization	Capital employed in the fishery is over and above that which is optimal in either an economic or biological sense. (See also decommissioning and overexploitation).
Overexploitation	Occurs when the fishery is producing less than it possibly could in terms of profits or catch, as the stock is less than the optimal stock size.
Pelagic	Pertaining to open ocean, generally denoting fishes dwelling in the upper layers of the water column, relatively fast moving, fast growing and often shoal forming (e.g. sardine, mackerel, tuna etc.). Distinguished as neretic (shallow pelagic zone over continental shelf), epipelagic (surface to 100 m depth), mesopelagic (200 to 1000 m depth) etc.
Plankton	Small floating organisms that drift more or less passively with ocean currents (distinguished from nekton which actively swim in the water), generally classified as phytoplankton (plant) and zooplankton (animal).
Phytoplankton	Microscopic (unicellular) plant life that floats in the ocean and forms the primary food for many animals, including fish.
Predator	An animal that captures and eats other animals (Carnivorous).
Quota	A limit on the weight of fish that may be caught in a particular stock or area; a bag limit is the quota (usually in numbers of fish caught) applied to recreational fisheries.
Recruitment	The addition of young to a fish stock.
Recruitment overfishing	A level of fishing in which the adult stock is reduced to the extent that recruits produced are insufficient to maintain the population.
Rent	The return to owner of the factor of production.
Revenue	Value of the catch that is landed.
Shellfish	Aquatic invertebrate animals having outer shell or inner bone-like structure ((like crab, shrimp, lobster, oyster, squid etc.)
Sensitivity analysis	Analysis involving varying the key parameters in a model and assessing the impact of changes in the parameters on the model solution.
Stakeholder	An individual or a group that has an interest in a resource and its use.

Subsistence fishery	A fishery in which indigenous people catch fish for their own consumption.
Survival rate	The percentage of individuals in a population that survive over a time interval (contrast to mortality rate)
Target species	A species for whose capture a fishing gear (operation) is designed (e.g. shrimp in the case of shrimp trawl); but a redundant term in a multi-species fishery
Traditional fishing zone	A marine area in which a group of people living on the adjacent coast has exclusive rights to fish on a subsistence basis.
Trawl (ing)	A bag-like conical net towed in water at bottom (bottom trawling) or column (mid-water trawling) and kept open by otter board (otter trawling) or by two boats (bull trawling); Trawler is a mechanised boat engaged in operation of trawl net
Technology creep	A gradual increases in the efficiency of fishing gear and methods, which results in increase in effective fishing effort.
Total allowable catch (TAC)	The maximum catch allowed (equal to the sum of ITQs) from a fishery in accordance with a specified management plan.
Total mortality	The sum of natural and fishing mortality